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SkyNews

NOVEMBER/DECEMBER 2015

The Canadian Magazine of Astronomy & Stargazing

PLUTO PORTRAITS

The most distant world ever explored by spacecraft has shown itself to be worth the trip

+

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COVER: After a decade-long voyage, NASA's New Horizons spacecraft reached Pluto on July 14, streaking past the icy world at 15 times the velocity of a rifle bullet. This enhanced-colour image was taken at a distance of 450,000 kilometres on the way in toward Pluto and shows features as small as two kilometres wide. Obvious differences in the composition and texture of Pluto's surface suggest that Pluto may still be geologically active. See Ivan Semeniuk's report on page 10. COURTESY NASA

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EDITOR'S REPORT

by Terence Dickinson

New Canadian Observatory's First Colour Photo

The Trottier Observatory at the Simon Fraser University Burnaby Campus is off to a fine start with a superb galaxy portrait and a full slate of public viewing

PINWHEEL GALAXY M101 This fine colour portrait of the sprawling 170,000-light-year-wide galaxy M101 in the constellation Ursa Major was taken using the new 28-inch telescope at the Burnaby Campus of Simon Fraser University. PHOTO BY HOWARD TROTTIER, SIMON FRASER UNIVERSITY

IF YOU READ the article on new public observatories in British Columbia in the July/August *SkyNews*, you will recall that the just opened Trottier Observatory on the Burnaby Campus of Simon Fraser University features an impressive PlaneWave CDK700 28-inch Dall-Kirkham reflector in a handsome dome. Like most university telescopes situated on campus, the Trottier Observatory is a teaching telescope that is open to the public on specified dates for celestial events such as solar and lunar eclipses and on some clear evenings for public viewing of planets, nebulas and galaxies.

But what is more unusual about this university observatory is that the telescope is also designed to take colour images of the wonders of the universe, as demonstrated here with this exceptional composite image of the giant spiral galaxy M101. Images like this require an expert astrophotographer at the controls.

Step forward Howard Trottier, a physics professor on the university staff who took the CCD images and processed them. He is promising more of the same as time and weather conditions permit. But with this image alone, the bar is already set high.

As explained in the July/August article, Howard is the brother of Lorne Trottier, who, along with his wife and daughters, is a Montreal-based philanthropist who has often supported scientific projects, particularly ones with a strong public-outreach component like this one.

Many university observatories offer peeks through teaching telescopes, but very few take public outreach a step further by sharing the majesty of the universe that

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only modern colour imaging offers to a wider audience. NASA's Hubble Space Telescope has taken the lead in this regard with a public-outreach department devoted to the preparation and dissemination of hundreds of images over the past quarter-century—many of them published prominently in this magazine.

The intrinsic beauty and majesty of the universe are, I would argue, what initially ignites so many of us—especially young people—with a fascination for astronomy.

NEW HORIZONS' NEXT ENCOUNTER

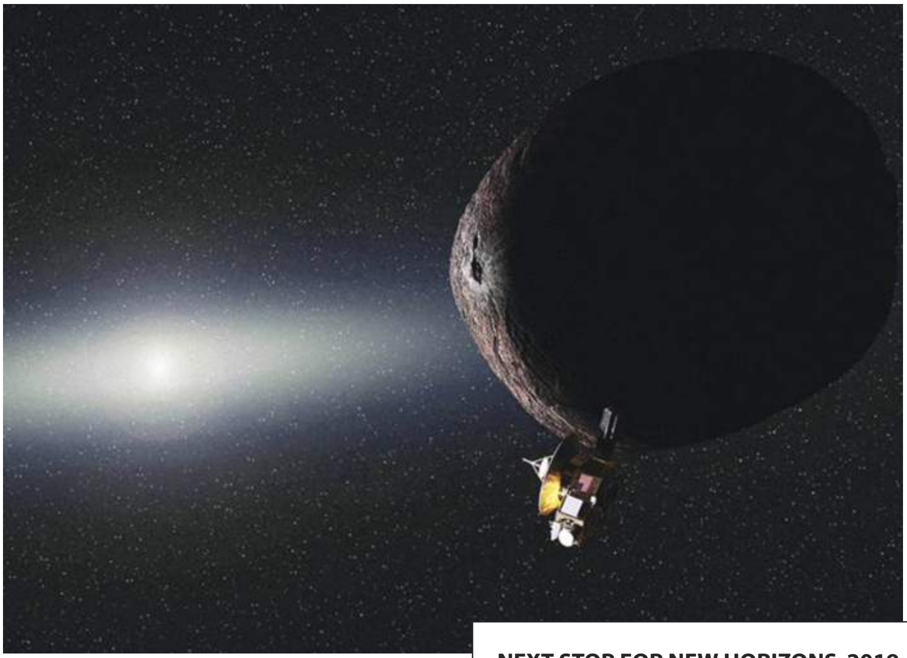
After swinging within one Earth diameter of Pluto and gathering hundreds of images of the remote icy world, what does the New Horizons spacecraft do for an encore?

It was always in the mission plans to visit a Kuiper belt object (KBO) after Pluto. The Kuiper belt is similar to the asteroid belt between the orbits of Mars and Jupiter, but it extends from Neptune's orbit to almost twice Neptune's distance from the Sun. More than 1,000 KBOs have been identified since the first one was discovered in 1992, and there are probably at least 100,000 greater than 100 kilometres in diameter out there.

Although the estimated total mass of the Kuiper belt is 100 times the mass of the asteroid belt, the KBOs are by no means bumping into one another. In fact, the objects in the Kuiper belt are more spread out than the asteroids. For this reason, NASA took several years selecting a KBO for New Horizons to visit. In late August, the next destination for the New Horizons mission following its historic Pluto flyby was announced: a small KBO known as 2014 MU69 that orbits more than a billion kilometres beyond Pluto.

Now the mission team needs to direct New Horizons toward the object late this year to ensure that the extended mission has healthy fuel margins. New Horizons is scheduled to perform a series of four manoeuvres in late October and early November to set its course toward 2014 MU69, nicknamed "PT1" (for "Potential Target 1"), which it is expected to reach close to January 1, 2019.

"Formed where it orbits now, 2014 MU69 is a great choice because it is just the kind of ancient KBO that the decadal survey desired us to fly by," says New Horizons principal investigator Alan Stern of the Southwest Research Institute in Boulder, Colorado. "Moreover, this KBO costs less fuel to reach than other candidate targets, leaving more fuel for the flyby and for ancillary science, as well as greater fuel reserves to protect against the unforeseen."



NEXT STOP FOR NEW HORIZONS, 2019
Plunging deep into the Kuiper belt beyond Pluto, New Horizons is scheduled to visit a 45-kilometre-diameter Kuiper belt object known as 2014 MU69. The spacecraft's cameras were designed for imaging in the dim light at the rim of the solar system. Beyond that, one more flyby may be attempted. ILLUSTRATION COURTESY SWRI

From the outset, New Horizons was designed to fly beyond the Pluto system and explore additional KBOs. The spacecraft carries extra hydrazine fuel for a KBO flyby; its communications system is configured to work from far beyond Pluto; its power system will operate for many more years; and its scientific instruments were designed to function in light levels much lower than it will experience during the PT1 flyby.

The 2003 National Academy of Sciences' Planetary Science Decadal Survey (*New Frontiers in the Solar System*) strongly recommended that the first mission to the Kuiper belt include flybys of Pluto and small KBOs in order to sample the diversity of objects in that previously unexplored region of the solar system. The identification of PT1, which is in a completely different class of KBO than Pluto, explains Stern, potentially allows New Horizons to satisfy those goals.

But finding a suitable KBO flyby target was no easy task. Starting its search in 2011 using some of the largest ground-based telescopes on Earth, the New Horizons team found several dozen KBOs, but none were reachable within the fuel supply aboard the spacecraft. The powerful Hubble Space Telescope came to the rescue in the summer of 2014, discovering five objects (since narrowed to two) within New Horizons' flight path. Scientists estimate that PT1 is roughly 45 kilometres across, which is only 0.5 to 1 percent of the size (and about 1/10,000 the mass) of Pluto. As such, PT1 is thought to be like the building blocks of Kuiper belt planets such as Pluto.

Unlike the asteroids, KBOs have been heated only slightly by the Sun and are thought to represent a well-preserved, deep-freeze sample of what the outer solar system was like following its birth 4.6 billion years ago.

"As the Pluto flyby has demonstrated so spectacularly, there's so much we can learn from close-up spacecraft observations that we'll never learn from Earth," says New Horizons science team member John Spencer. "The detailed images and other data that New Horizons could obtain from a KBO flyby will revolutionize our understanding of the Kuiper belt."

Now 4.9 billion kilometres from Earth, the New Horizons spacecraft is just starting to transmit the bulk of the images and other data stored on its digital recorders from its historic July encounter with the Pluto system. The spacecraft is healthy and operating normally. ✦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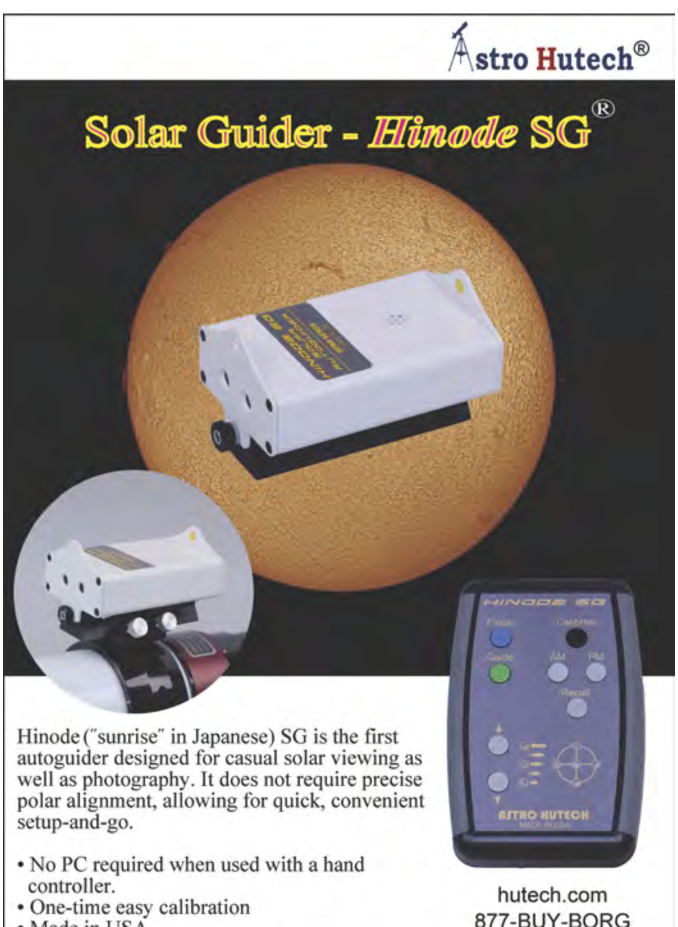
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METEOR WATCH

I combined all the meteor images from my photo session on the peak night of the Perseids (August 12/13) into a single composite image. There are 15 trails on the image. One bright trail—the short one at upper right—is not a true Perseid. Astronomers call such meteors sporadics. The one at the lower right above the tree line is a faint aircraft or satellite trail. All the rest are Perseids. One Perseid appears to be in front of a tree. This happened because I used an image partway through the night as the main background, and this Perseid appeared on a later image that was clear of the tree. These 13 Perseids are only a few of the many that were seen with the unaided eye, since the camera sensor is not sensitive enough to capture the fainter ones. The best way to observe a meteor shower is still by eye, as was proved during a 15-minute interval in which the group I was observing with counted 48 meteors. A report by the International Meteor Organization on the worldwide effort to observe the Perseids states that some observers saw bursts of more than twice the predicted number of 90 per hour—just as our group observing from the Bluewater Astronomical Society's Fox Observatory site did that same night.

John Hlynialuk
Owen Sound, Ontario

PLATO'S CHALLENGE

The images of the lunar crater Plato by Gary Seronik and NASA's lunar orbiter (*SkyNews*, Sept./Oct., page 42) caught my attention because I had just imaged it with my Meade 16-inch Schmidt-Cassegrain.

Jack Newton
Osoyoos, British Columbia

SUBMITTING LETTERS AND PHOTOS

SkyNews *editor Terence Dickinson welcomes your letters about anything you read in the magazine. Submission of photos as attachments is encouraged. Send photos in jpeg format, keeping compressed file size to less than 3MB, to: dickinsonSkyNews@gmail.com.*

PLUTO REVEALED

After a decade-long voyage to the rim of the solar system, NASA's New Horizons spacecraft gathers the first close-ups of Pluto and its large moon Charon

by Ivan Semeniuk

THREE MONTHS AFTER NASA's New Horizons probe sailed within one Earth diameter of Pluto, Kelsi Singer still marvels at the dwarf planet's capacity to astonish even those who spent years planning for the July 14 flyby.

A postdoctoral researcher with the mission, Singer was on hand at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, when, just hours after the historic encounter, the first close-up images from Pluto began popping up on computer screens, eliciting a chorus of gasps.

Even at first glance, scientists could see that Pluto is a diverse and dynamic world, possibly more dynamic than can easily be explained by current theories. But how it came to be so and what that says about similar objects patrolling the fringes of the solar system in the region known as the Kuiper belt remain tantalizingly open questions.

"It's really forcing us to think about how these midsized bodies can still be active into the present time," says Singer.

Thanks to New Horizons, Pluto has been transformed from a world of mystery into a world with a history. Its rigid crust, composed primarily of water ice, boasts mountain ranges as tall as the Rockies and linear scars hundreds of kilometres long. Some features are suggestive of past tectonic activity. Some look recent. Taken together, they raise the possibility that Pluto's complex surface is concealing an even more interesting and energetic interior.

It's clear that parts of Pluto's surface are very young, says Francis Nimmo, a New Horizons team member and planetary scientist at the University of California, Santa Cruz. "What is not clear is whether their youth is due to relatively surficial processes or to deeper-seated activity."

The difference is crucial. Because of its elongated orbit, Pluto receives much more energy from the Sun at certain times during its 248-year orbit than at others. As a result, its nitrogen atmosphere is subjected to a seasonal cycle of freezing and sublimation that could be altering parts of Pluto's surface over time through deposition and erosion by nitrogen ice. But if some of the features revealed by New Horizons can only be explained by internal forces, it could mean that Pluto has retained enough heat billions of years after its formation to support a layer of water deep below the surface, sandwiched between an icy mantle and a rocky core.

A focal point for understanding what is really happening on Pluto is the dwarf planet's most prominent feature: a heart-shaped patch of bright material dubbed Tombaugh Regio by mission scientists in honour of Pluto's discoverer, astronomer Clyde Tombaugh. The contrast between this area and its darker surroundings was first detected decades ago by Earth-based studies that measured a regular change in Pluto's brightness as it rotates on its axis every 6.4 days. The feature became more sharply defined by New Horizons in the days leading up to the probe's rendezvous with Pluto, and it was a natural target for more detailed investigations.

During its closest approach, New Horizons zoomed in on the left lobe of the heart, now called Sputnik Planum, which appears brighter and more distinct. Its boundaries reveal an assortment of suggestive features and physical contrasts with the adjacent terrain. In some places, glaciers of nitrogen ice seem to flow outward from the edges of the plain, inundating the landscape beyond like a slow-motion flood. In others, Sputnik Planum looks more like an advancing desert, where bright dune fields have crept over a more ancient and much darker surface.

"My focus now is to understand the seasonal processes on Pluto that create this contrast and to determine whether they are effective on timescales of decades or millions of years," says Richard Binzel, a planetary scientist at the Massachusetts Institute of Technology.

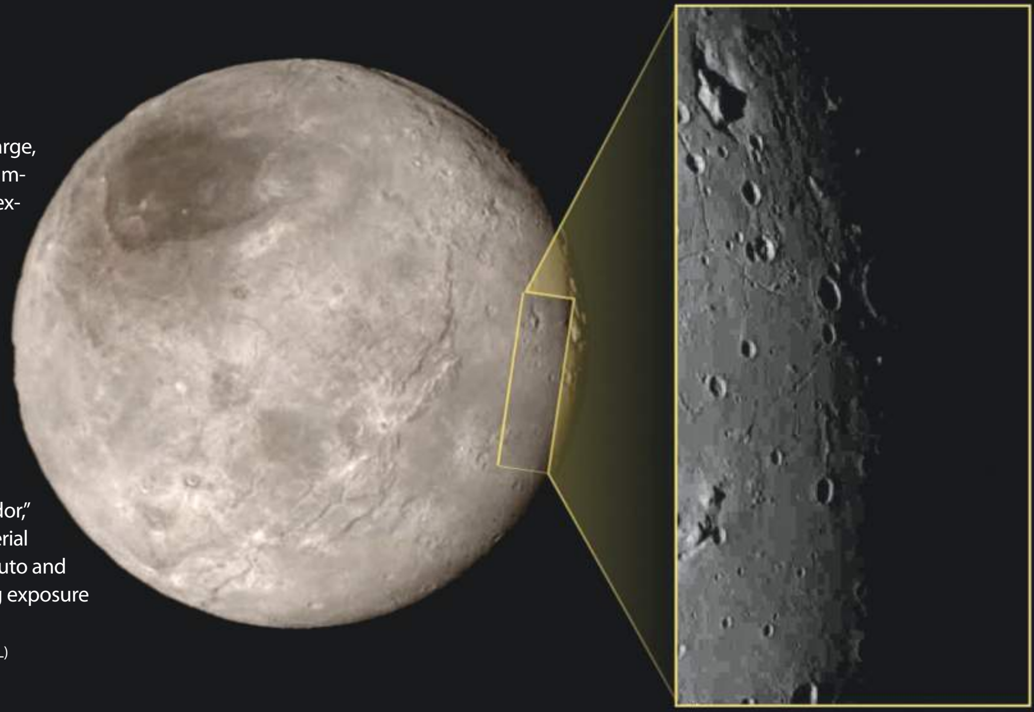
Initial data reveal that Sputnik Planum is composed of frozen nitrogen, with methane and carbon monoxide also in the mix. It is utterly without craters, indicating a young surface, and is subdivided into "polygons," smaller units a few tens of kilometres in size that resemble bubbles or cells. Some are rimmed by darker material or by what seem to be small, rounded hills.

On Earth and on Mars, polygonal features can arise due to contraction, when cooling or drying material shrinks and separates. Cracked mud in the desert and columnar basalt in ancient volcanic flows are both examples of this process. Alternatively, the polygons of Sputnik Planum could be convection features—places where icy material is slowly churning to release energy from below. But either way, mission scientists must try to account for why this one area on Pluto seems so different from anywhere else.

"We really don't have any confirmed ideas at this time," says Singer. "It's mostly just people scratching their heads and trying to come up with something."

A better sense of Sputnik Planum's profile in three dimensions

BUSY WORLD Its diverse and sharply contrasting landforms suggest that Pluto has undergone a complex geological evolution that may still be under way. In this dramatic global view from the New Horizons probe, the most striking feature is Sputnik Planum (centre), a bright deposit of frozen nitrogen and other gases. The image is colour-enhanced to highlight subtle differences in surface composition. COURTESY NASA/APL



SPOT ON Pluto's large, 1,270-kilometre-diameter moon Charon exhibits giant cliffs, chasms and a peculiar mountain peak (inset, top left) that resembles a castle surrounded by a moat. A prominent dark spot at Charon's north pole, dubbed "Mordor," may consist of material transported from Pluto and discoloured by long exposure to cosmic rays.
COURTESY NASA/APL (ALL)

TWO MOONS Surface variations on Nix and Hydra, two of Pluto's smaller moons, are revealed in these composite images. The irregular pair measure 42 and 55 kilometres long, respectively. The image of Nix has been colour-enhanced to reveal a dark reddish patch, while the black and white photo of Hydra shows a large impact crater at upper right.

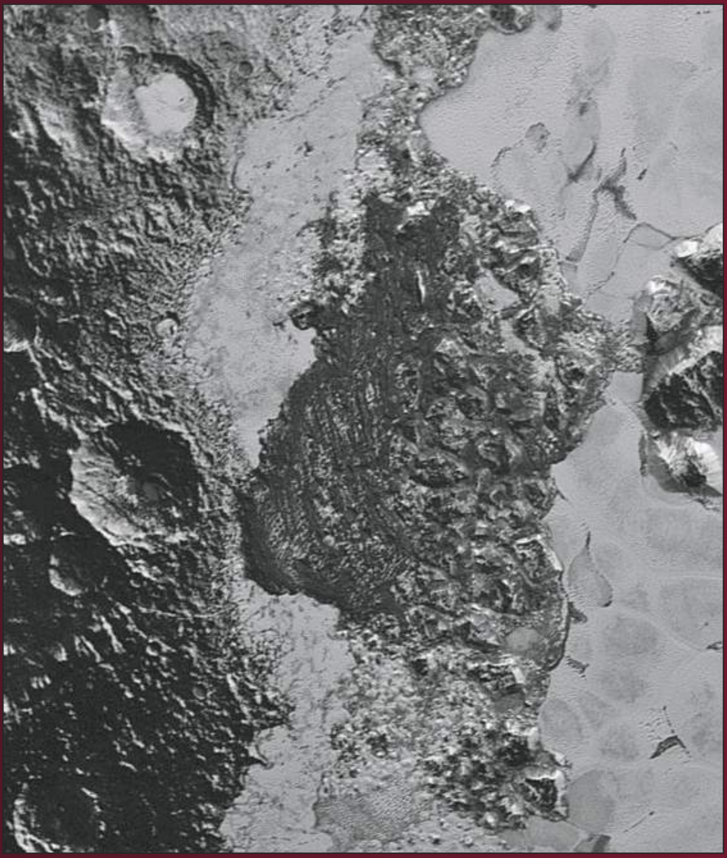
HAZY LAYERS Following closest approach, New Horizons turned around to image Pluto's tenuous atmosphere backlit by the Sun. When specially processed, the view reveals multiple layers of haze that sit tens of kilometres above the surface.

would help, says Singer. The plain could be flat, domelike or depressed like a shallow bowl. Each possibility would say something different about the feature's true nature. A clearer picture should emerge later this fall as more images collected during the flyby are streamed back to Earth, providing views of Sputnik Planum from multiple angles.

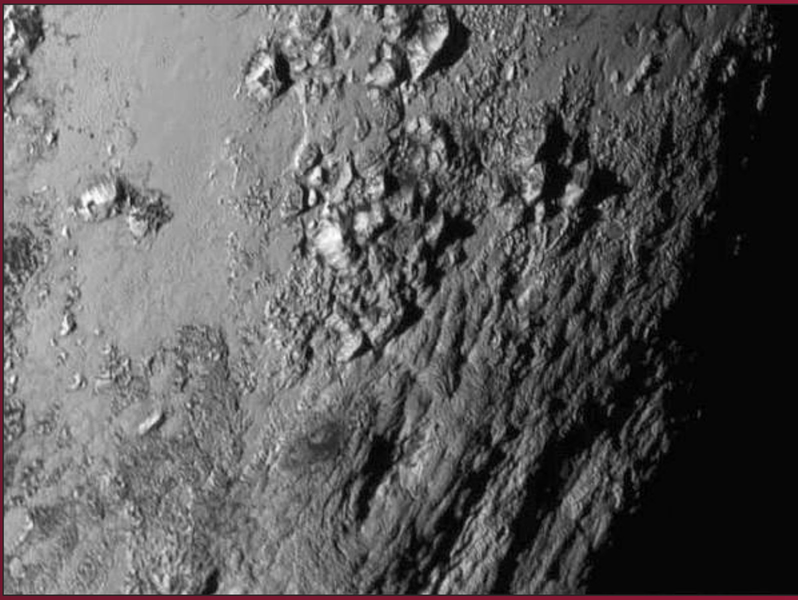
Meanwhile, Singer and New Horizons principal investigator Alan Stern have been working on another question that may ultimately tie back to Sputnik Planum.

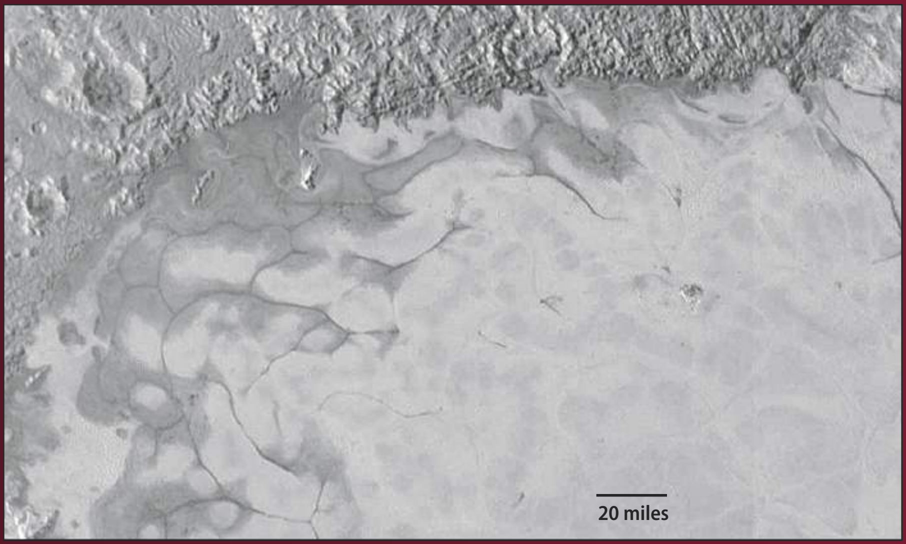
New Horizons has confirmed that Pluto must be losing its thin nitrogen atmosphere to space at the rate of hundreds of tonnes per hour. Even if the loss occurs only when Pluto is nearer to the Sun in its orbit, the atmosphere must somehow be replenished, or it would be gone by now. In a paper published in *The Astrophysical Journal Letters* over the summer, Stern and Singer calculate that comet impacts can neither deliver nor excavate enough nitrogen from the surface to make up for the loss.

Sputnik Planum clearly offers a larger reservoir of frozen nitro-



LIGHT AND DARK The bright, frozen material at the western edge of Sputnik Planum has a windblown look that includes dunelike features. The smooth plain gives way abruptly to a dark-coloured terrain called Cthulhu Regio (left). An abundance of craters in the dark area suggests that this is one of the oldest parts of Pluto's surface.





DRAMATIC RELIEF A range of sharp peaks called Norgay Montes towers about 3,500 metres above Sputnik Planum. The mountains do not appear to have been formed by an impact but, rather, have been thrust up by internal forces that are not yet understood.

ICY FLOW The surface of Sputnik Planum forms a curious cell-like pattern. At the edge of the plain, there is evidence that nitrogen ice has been spilling out onto the jagged terrain at upper right. With Pluto's surface temperature of –235°C, water ice is as brittle as rock, but nitrogen ice can still flow as glaciers do on Earth.

gen, says Singer, but it would not be enough to maintain Pluto's atmosphere over geologic time. "We think it's a good resupply station, but the nitrogen still has to get to Sputnik Planum in order to resupply the atmosphere."

The implication is that nitrogen is somehow venting up from Pluto's interior. If so, it may well be emerging at Sputnik Planum, says Singer, offering more evidence of an active interior.

New Horizons science team members caution that they are far from ready to make definitive conclusions. The full data set from the flyby, including dozens more images, will require nearly another full year to transmit back to Earth. During that time, Pluto's story will only grow richer in detail and nuance. The most distant world ever explored by spacecraft has shown itself to be worth the trip and a captivating spokesplanet for an entire domain of worlds beyond the orbit of Neptune. ✦

Ivan Semeniuk is a science reporter for The Globe and Mail *newspaper and website. His columns appear regularly in* SkyNews.

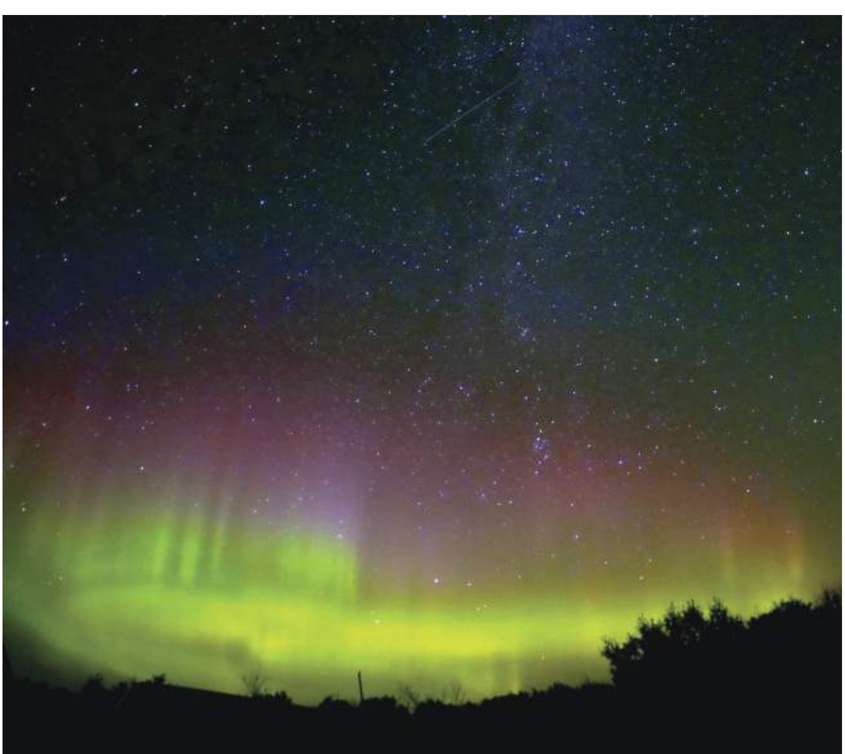
LIGHTS, CAMERA, ACTION!

Meteors topped astro-imagers' agendas last summer, along with auroras and star-trail exposures

▶ **INTENSE AURORA BEFORE DAWN** Edmonton astrophotographer Ray Wiens was under the dark skies of Alberta's Elk Island National Park on August 23 when the sky lit up with a pulsing aurora glow. Because the auroral curtains were moving so rapidly, Wiens decided to use ISO 6400, which allowed 2-second exposures on his Sony α7R camera with a 28mm f/2.8 lens. "The aurora extended south as far as 25 degrees from the southern horizon," he says. "It was at its best just before dawn."

▼ **4.5-HOUR STAR-TRAIL EXPOSURE** From a photogenic site near Killarney, Ontario, a village on the north shore of Georgian Bay, astro-imager Bill Gardner recorded this extended time exposure using a Canon 40D with a 10mm super-wide-angle lens at f/5. A modest aurora added colour to the scene. It takes a very dark sky for this type of sky portrait to work, along with low humidity or a low-voltage heater to prevent dew from fogging the lens.

▲ **NIGHT OF THE PERSEIDS** *SkyNews* received many fine images of the Perseid meteor shower, and this photo by Ontario photographer Matt Quinn was one of the best. It's a composite of about 50 images taken from midnight to 4 a.m. on August 13 from the observing site of the Kitchener-Waterloo Centre of the RASC.



▲ **AURORA AND MILKY WAY** "Between the aurora, the Milky Way and the Perseids, I didn't know where to look," says Tim Yaworski of his night under the dark skies near Colonsay, Saskatchewan, on August 12. This stunning 20-second exposure was shot with a Fujifilm X-E2 camera using a Bower 8mm lens at f/2.8 and ISO 1600.

▲ **PERSEID METEOR FLASHES THE MILKY WAY** The annual Starfest star party in Ontario this August coincided with the peak of the Perseid meteor shower. Better-than-average numbers of the cosmic streakers were reported this year. Rob Lenz of St. Catharines, Ontario, captured this one at Starfest with a Canon T1i and Rokinon 16mm lens exposed for about 20 seconds at f/2.

by Gary Seronik

A Visit to Mare Humorum

This overlooked lunar 'sea' features a host of remarkable sights

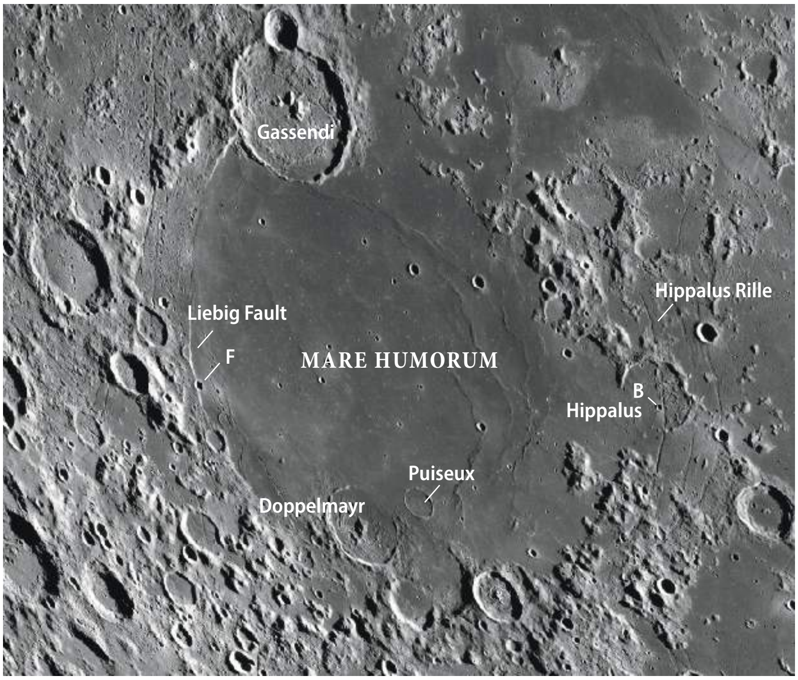
BEFORE I DEPARTED FOR MY FIRST TRIP TO ITALY many years ago, a friend warned me that the place was overrun with tourists. And it was true. The Colisseum and Forum in Rome were packed with camera-toting visitors, as was the famed Uffizi Gallery in Florence. But I found that when I strayed off the beaten path even just a little, the country seemed almost deserted. It turns out that tourists tend to stick to the well-known locations they've seen on TV or read about in guide books and magazines. The same holds true for lunar tourists. The biggest attractions get all the attention, while some wonderfully intriguing corners of the Moon are neglected. Mare Humorum is one of those overlooked corners.

Perhaps one reason Humorum is underappreciated is because it lies at the southern end of an enormous span of maria that encompasses much of the Moon's western hemisphere (remember that east and west on the lunar surface are opposite sky directions). Spanning roughly 380 kilometres, Mare Humorum is the placid surface of the Humorum impact basin, which was violently excavated some 3.9 billion years ago. That makes Humorum a little older than the hemisphere-dominating Imbrium Basin to the north.

In many ways, Humorum mirrors the well-known Nectaris Basin, which I highlighted in the July/August issue on page 14. They're about the same size, and each features a particularly impressive crater on its mare shore. In Humorum's case, that crater is 110-kilometre-wide Gassendi. It's the region's star attraction and worth a long, careful look with your telescope. Gassendi's floor is crisscrossed by an intricate network of fine rilles, the most prominent of which are found south and east of the central mountain complex. Good seeing conditions, favourable illumination and high magnification are a must for seeing them.

Mare Humorum's most conspicuous set of rilles is located on its eastern shore, near the lava-flooded crater Hippalus, which is something of a glorious mess. Its mare-facing rim is submerged under Humorum lavas, while the opposite edge was damaged

SEA OF MOISTURE The prime time for viewing the Mare Humorum region is a waxing gibbous Moon or a waning crescent Moon in the morning sky. PHOTO BY GARY SERONIK



OFF THE BEATEN TRACK Mare Humorum is at the heart of a lunar wonderland of rilles, faults and partially submerged craters. When the terminator is nearby, you can easily spend hours exploring this fascinating region with a telescope. COURTESY LRO/NASA

by a later impact. Hippalus B, a five-kilometre-diameter bowl-shaped divot, adorns the crater's floor and provides a handy landmark to one of the area's star attractions. Just east of this little crater, you'll find a prominent rille that cuts across Hippalus. This is merely a 60-kilometre segment of the 240-kilometre-long Hippalus Rille system that curves along the eastern edge of Mare Humorum. The rille's dimensions vary along its length, but the widest parts are three to four kilometres across and more than 100 metres deep. That's wider than the better-known Hyginus Rille.

On the western shore of Humorum, you'll find another linear feature, though it's a bit trickier to see. The Liebig Fault traverses 180 kilometres and is divided by the eight-kilometre-wide simple crater Liebig F. Although rilles and faults look similar in the eyepiece, they're actually quite different landforms. One is a channel (rille); the other is more like a cliff. The Straight Wall is probably the best-known example of a lunar fault, but in truth, neither it nor the Liebig Fault is a particularly dramatic landform. Although the top of the Liebig Fault is 400 metres above the floor of Mare Humorum, its slope is modestly inclined at an angle of roughly 11 degrees. You could easily walk up this "cliff."

Like Nectaris, Humorum also has a collection of "ghost" craters. The biggest and visually most rewarding is Doppelmayr. At 64 kilometres wide, it's sufficiently large to have a central mountain peak tall enough to survive the flood of mare lavas that rushed in after the crater's northeastern wall was breached. Nearby is an even ghostlier crater, 25-kilometre-diameter Puiseux. It didn't fare quite as well as its neighbour. All that remains of Puiseux is the very top of its rim and the barest hint of a central peak.

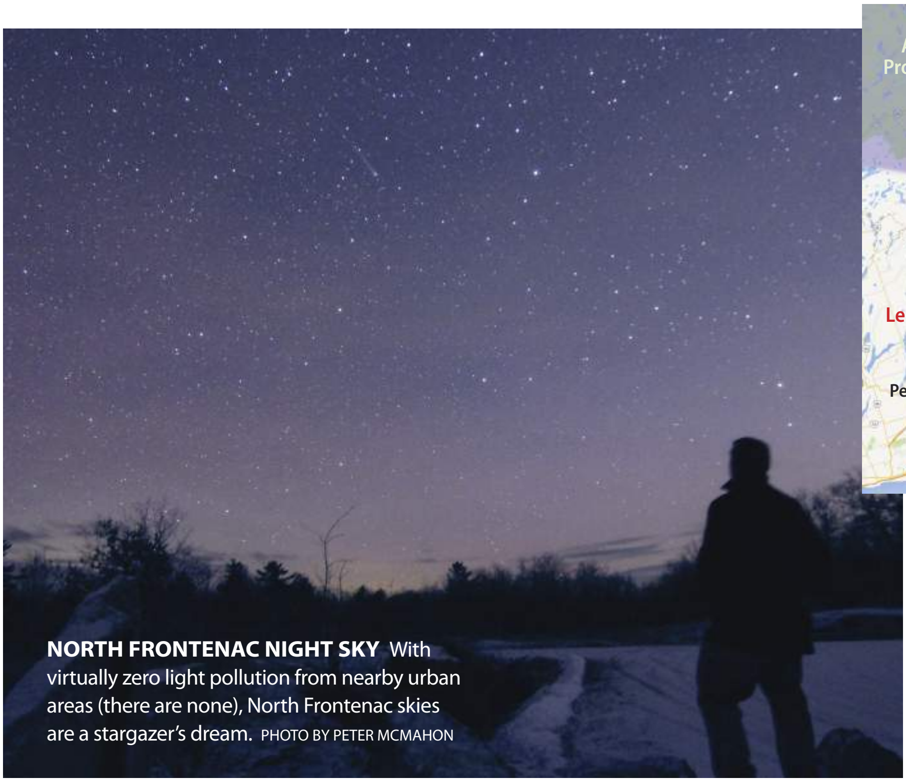
The next time the terminator is nearby, give Humorum a visit. There's far more to see than the handful of features described here. I think you'll find the region as rewarding as any of the best-known locations on the lunar surface. ✦

A veteran lunar observer, Gary Seronik is the editor of Antonín Rükl's classic Atlas of the Moon *and Charles A Wood's* The Modern Moon. *He is also editor of this magazine's website, SkyNews.ca.*

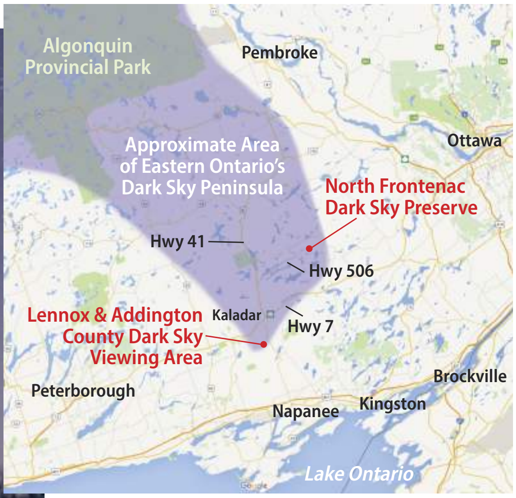
by Peter McMahon

Eastern Ontario's Inland 'Dark Sky Peninsula'

Near Kingston and Napanee in Ontario, Highway 401—the main corridor across Canada's most populous province—comes close to a region of very dark skies



NORTH FRONTENAC NIGHT SKY With virtually zero light pollution from nearby urban areas (there are none), North Frontenac skies are a stargazer's dream. PHOTO BY PETER MCMAHON



FOR THE PAST FEW decades, southern Ontario has become notorious for pervasive light pollution that spreads out from urban centres for tens to hundreds of kilometres. While many unspoiled stargazing spots exist north of a line that runs roughly from Owen Sound to Huntsville to Pembroke, there are occasional dark oases south of that line, but virtually none of them are within a couple of hours of most Ontarians' homes. Even fewer are designated dark sky preserves with astronomy infrastructure such as electricity, cell or Internet access and open level spaces for telescopes.

Since about the year 2000, however, amateur astronomers have been testing locations in a "dark peninsula" effectively devoid of urban light pollution that extends southeast from Algonquin Provincial Park to about 40 kilometres north of the town of Napanee. Highway 41 from Napanee to Pembroke runs through the middle of this relatively sparsely populated zone.

The first dark sky preserve in this area, spearheaded by *SkyNews* editor Terence Dickinson, is the excellent Lennox & Addington County Dark Sky Viewing Area, which opened in 2012. Located a half-hour north of the Highway 401 interchange with Highway 41 at Napanee (west of Kingston), this pristinely dark astronomy destination, complete with concrete observing pad, parking area, interpretive signage and washroom, is maintained year-round. About one hour north of the Lennox & Addington site is the North Frontenac Dark Sky Preserve, established in 2013, making this the first municipality in Canada to receive such a title, as designated by The Royal Astronomical Society of Canada (RASC).

The North Frontenac Township site has a house-sized concrete observing pad with unimpeded horizons. The site is near the emergency services helipad on Road 506, half an hour east of Highway 41.

"Hands down, my favourite thing to see here is the naked-eye Milky Way," says seasoned amateur astronomer and Toronto RASC asteroid guru Guy Nason. "It is so vivid, you feel as if you can reach out and touch it." Nason and his wife built a cottage here in the 1990s because the area best suited their interests in paddling and astronomy. "I actually built the observatory first, then the cottage," he says. "Obviously, I had my priorities straight."

A regular slate of stargazing evenings, hosted by amateur astronomers from urban centres across southern Ontario, draws

people from Ottawa, Kingston and as far away as Toronto, Montreal and even the United States.

"I could not believe how clear the rings around Saturn were when they showed us here one night," says township mayor Ron Higgins. "The colour and clarity…and the shape and form of one galaxy we saw looked just like what you'd see on a TV science documentary."

The site is open daily year-round and offers electricity, local tourist info, solid cell service for calls and data, washrooms, picnic tables and benches surrounding the observing pad.

While several campgrounds are located a few minutes from the observing site, as well as Bon Echo Provincial Park, more civilized accommodations await roughly 20 minutes to the south at Marble Lake Lodge, Fernleigh Lodge, Myers Cave Resort and a number of other cabin-based properties.

There are also many local bed and breakfasts, and the township is planning to offer more year-round accommodations as interest in the dark skies grows.

LONG LIVE THE DARK

The views at night here are almost addictive. When asked what else is worth a look, Nason raves, "Just the staaars," with the enthusiasm of an overstimulated six-year-old. "During my first look at the Dumbbell Nebula here through my 12.5-inch Newtonian scope," he says, "the central star jumped out at me.

"Not only is the Andromeda Galaxy viewable without optical aid, but the dimmer Triangulum Galaxy is visible to the naked eye, even to my 68-year-old peepers. When the Leonids were especially bright, I just pushed the roof off our observatory. The meteors were so bright, and you could see so many more faint ones that you wouldn't have otherwise seen. No one ever sees the zenith hourly rate, but here, you come close." ✦

Peter McMahon is manager of the Ontario Planetarium and the Jasper Planetarium and currently serves as Jasper Dark Sky Preserve's astronomer in residence.

For more on the activities in the North Frontenac Dark Sky Preserve as well as the initiatives the township has taken to keep light pollution at bay, go to WildernessAstronomy.com and click on the Magazine link.

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- Up to 8 seconds' exposure @ 2048 x 1536
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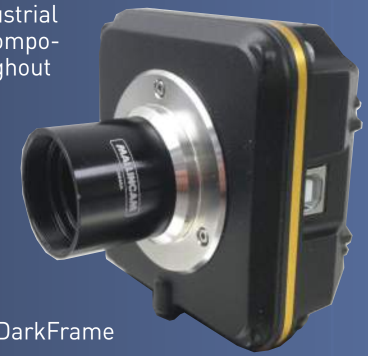


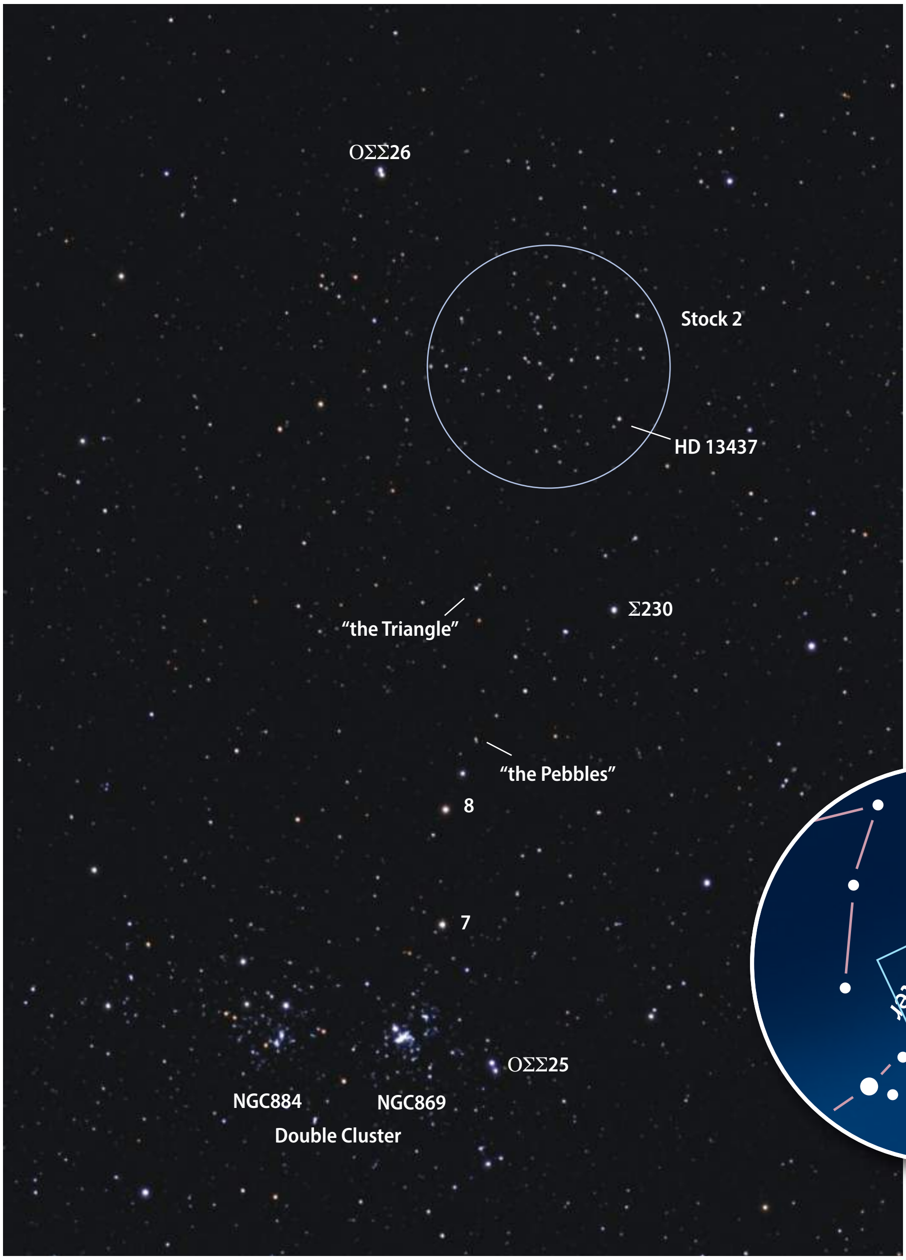
$549.99

TAKING STOCK IN CASSIOPEIA

Near the famous Double Cluster in Perseus is an often-overlooked celestial attraction

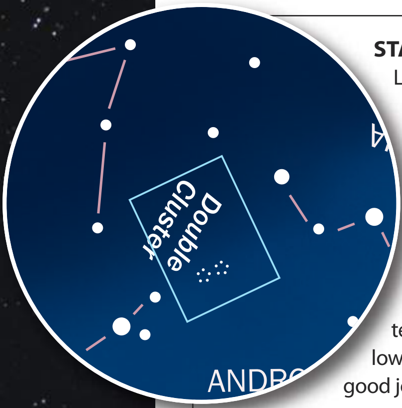
by Ken Hewitt-White

THE "ATTRACTION" is **Stock 2**, a sparse open star cluster set against the Milky Way in eastern Cassiopeia. The second of 25 previously unrecognized clusters studied by German astronomer Jürgen Stock in the early 1950s, this unheralded object is only about 1,000 light-years away—roughly one-seventh the distance of its celebrated neighbour, the Double Cluster—and spans one full degree of sky. Join me in my suburban yard as I explore Stock 2 and the region around it using my 4¼-inch f/6 Newtonian reflector.



Stock 2 hugs the Cassiopeia-Perseus border two degrees northwest of the Double Cluster. Indeed, Stock 2 seems tethered to the dazzling Double Cluster by a chain of 6th- to 10th-magnitude stars. From a wide double star immediately west of **NGC869** (the Double Cluster's western half), the starry chain curves along a northeast-through-northwest arc for 1½ degrees, then turns north for ½ degree to Stock 2. This connecting region offers a few sights of its own, so let's apply 50x to my small reflector and star-hop to Stock 2.

We begin at the Double Cluster just west of NGC869. The 6.5- and 7.4-magnitude stars of **Struve 25** (ΟΣΣ25) are 103 arc seconds apart. The slant of the pairing is strikingly similar to that of the even wider 6.6-magnitude duo that dominates NGC869. Struve 25 points to the next bright star in the chain, 6.0-magnitude **7 Persei**. This yellow sun is accompanied by a 9.6-magnitude companion two arc minutes southeast. Northward is another yellow star, 5.8-magnitude **8 Persei**. The chain then arcs northwestward past a 7.5-magnitude star to a fairly faint dou-



STALKING STOCK 2 Located conveniently near the famous Double Cluster in Perseus, the fainter but still obvious cluster Stock 2 is an easy and beautiful binocular target in dark skies. Any small telescope used at its lowest power will do a good job on Stock 2 as well.

MAIN CHART BY GLENN LEDREW

ble I call **the Pebbles**. Its 9.6- and 10.1-magnitude stars are 38 arc seconds apart. A few dots farther along is a tighter binary, **Struve 230** (Σ230), comprising 7.9- and 9.4-magnitude components separated by 25 arc seconds. (Remember that celestial north is toward Polaris, not compass north.)

Allow me to detour from Struve 230 to a tiny trio of stars 20 arc minutes to the east-northeast. The threesome forms a right-angle triangle whose vertex is marked by an 8.1-magnitude star. A 10.0-magnitude star lies 56 arc seconds to the northwest, and a 10.8-magnitude star is barely visible 37 arc seconds to the northeast. I call this teeny triangle (surprise!) **the Triangle**. With some minor re-aiming, I can include the Triangle, the Pebbles and Struve 230 in one field of view. Returning to Struve 230, I see a 6.4-magnitude star in the northwest part of the field that marks the chain's turning point. From there, it's straight north to Stock 2. I usually reduce to about 25x before making the final nudge to the big cluster.

The *Millennium Star Atlas* plots 95 stars down to magnitude 11.0 inside the one-degree-wide circle defining Stock 2. The cluster's brightest star, **HD 13437**, is magnitude 7.6 and comes with a 9.4-magnitude companion. HD 13437 is well positioned, for it marks the place where the chain of stars I describe above connects to Stock 2. From that relatively prominent point, the coarse collection of dimmer stars fans out in a northeasterly direction. I picture the fan-shaped cluster and the bent star chain as a flower atop its stem. My imaginary flower opens in the direction of a "bee" symbolized by **Struve 26** (OΣΣ26), an eye-catching double to the northeast. The 6.9- and 7.2-magnitude stars, 63 arc seconds apart, aim at the cluster. Interestingly, Struve 26's slant is similar to that of our two other bright sets: the pair within NGC869 and Struve 25 beside it.

Stock 2 looks best when using a long-focal-length eyepiece coupled to a short-focal-length telescope. For example, a wide-angle 30mm eyepiece harnessed to my small f/6 reflector provides a 3.2-degree field of view—perfect for revealing the breadth of this cluster and its rich surroundings. North Vancouver observer David Rodger has employed similar optics to perceive an interesting pattern *inside* Stock 2. "At its core," writes David, "is a quadrilateral that reminds me of a broader Hercules Keystone. From this, several lines of stars trickle off. Some of these form a big, ragged plus sign oriented north-south-east-west."

I hope you'll "take stock" of this under-appreciated cluster yourself. And remember, its subtle features look even better well away from city lights. ✦

Contributing editor Ken Hewitt-White has observed deep-sky fuzzies over southern British Columbia for more than four decades.

STAR CHART *for Late Autumn*

OUR CHART SHOWS the major stars, planets and constellations visible from Canada and the northern United States within one hour of these times:

EARLY NOVEMBER: 11 P.M.; LATE NOVEMBER: 10 P.M.
EARLY DECEMBER: 9 P.M.; LATE DECEMBER: 8 P.M.

THE EDGE OF THE CHART represents the horizon; the overhead point is at centre. On a moonless night in the country, you will see more stars than are shown here; deep in the city, you will see fewer. The ecliptic is the celestial pathway of the Moon and planets. The star groups straddling this line are known as the zodiac constellations. The Moon is shown for selected dates.

USING THE STAR CHART OUTDOORS: The chart is most effective when you use about one-quarter of it at a time, which roughly equals a comfortable field of view in a given direction. Outdoors, match the horizon compass direction on the chart with the actual direction you are facing. Don't be confused by the east and west points on the chart lying opposite their location on a map of the Earth. When the chart is held up to match the sky, with the direction you are facing at the bottom, the chart directions match the compass points. For best results when reading the chart outdoors, use a small flashlight heavily dimmed with red plastic or layers of brown paper. Unfiltered lights greatly reduce night-vision sensitivity.

CELESTIAL CALENDAR

NOV. 1 Daylight time ends, standard time begins (set clocks back one hour)

NOV. 2 Venus and Mars ¾° apart today and tomorrow in morning sky

NOV. 3 Last-quarter Moon

NOV. 6 👁 Waxing crescent Moon 2° south of Jupiter in morning sky

NOV. 7 👁 Waxing crescent Moon 2.5° below Venus and 3.5° below Mars in morning sky

NOV. 11 New Moon, 12:47 p.m., EST

NOV. 17 Leonid meteor shower peaks (favourable moonset at 10:30 p.m., local time)

NOV. 18 Neptune resumes eastward prograde motion

NOV. 19 First-quarter Moon

NOV. 25 Full Moon, 5:24 p.m., EST

NOV. 26 Nearly full Moon occults Aldebaran in predawn hours

NOV. 30 Saturn at superior conjunction behind Sun

DEC. 3 Last-quarter Moon

DEC. 4 Waning crescent Moon 3° below Jupiter in morning sky

DEC. 6 Waning crescent Moon between Mars and Spica in morning sky

DEC. 7 👁 Waning crescent Moon 1° from Venus and 4.5° from Comet Catalina in morning sky, followed by a daytime occultation of Venus by the Moon

DEC. 11 New Moon, 5:29 a.m., EST

DEC. 13 👁 Geminid meteor shower peaks tonight and tomorrow under ideal moonless conditions in evening sky

DEC. 18 First-quarter Moon

DEC. 19 Waxing gibbous Moon 2° below Uranus in evening sky

DEC. 21 Solstice (11:48 p.m., EST); winter officially begins in northern hemisphere

DEC. 23 Waxing gibbous Moon 1° to 2° from Aldebaran in evening sky; Mars 3° north of Spica for next three mornings

DEC. 25 Full Moon, 6:11 a.m., EST

DEC. 28 Mercury at greatest angle away from Sun (20°) low in evening sky

DEC. 30 Waning gibbous Moon 5° from Jupiter (rising at midnight)

JAN. 1 👁 Comet Catalina ½° from Arcturus in predawn hours

👁 *Impressive or relatively rare astronomical event*

THE PLANETS

MERCURY appears only briefly this season at the end of the year, as it reaches its greatest elongation away from the Sun on Dec. 28, when it shines low in the southwest at magnitude –0.5.

VENUS shines in the morning sky, dimming from magnitude –4.5 to –4.1 as it descends toward the Sun on the far side of its orbit. Venus passes just ¾° from Mars on Nov. 2. Close conjunctions with the waning crescent Moon occur on Nov. 7 and again on Dec. 7, when the Moon actually occults Venus during the daytime.

MARS appears in Virgo in the morning sky, brightening from magnitude 1.7 to 1.4 as it gradually climbs away from the Sun. Venus and Mars are in close conjunction on Nov. 2. From Dec. 23 to 25, Mars passes 3° above Spica.

JUPITER appears in Leo, brightening from magnitude –1.8 to –2.1, rising about 3 a.m. in early November but coming up at midnight by year's end. Jupiter partakes in conjunctions with the waning Moon on the mornings of Nov. 6, Dec. 4 and Dec. 31.

SATURN is lost from view this season, as it reaches "superior conjunction" behind the Sun on Nov. 30.

URANUS can be seen in the south during early-evening hours this season as a 5.7-magnitude object in Pisces. Look for it about 2° below the fourth-magnitude star epsilon Piscium.

NEPTUNE is well placed for evening viewing this season in Aquarius, in the south to southwest. Look for it as a 7.8-magnitude bluish "star" about 4° west of the fourth-magnitude star lambda Aquarii. Neptune stops its westward retrograde motion on Nov. 18, after which it resumes its normal eastward "prograde" motion.

Cartography and design by Roberta Cooke. Base chart data derived from maps drawn by Roy Bishop for the *Observer's Handbook*, published by The Royal Astronomical Society of Canada.

For more detailed information, see the *Observer's Handbook 2015*, published by The Royal Astronomical Society of Canada (www.rasc.ca or 888-924-7272).

ROTATING NIGHT SKY: During the night, the Earth's rotation on its axis slowly shifts the entire sky. This is the same motion that swings the Sun on its daily east-to-west trek. The rotational hub is Polaris, the North Star, located almost exactly above the North Pole. Everything majestically marches counterclockwise around it, a motion that becomes evident after about half an hour.

CONSTELLATIONS: The star groups linked by lines are the constellations created by our ancestors thousands of years ago as a way of mapping the night sky. Modern astronomers still use the traditional names, which give today's stargazers a permanent link to the sky myths and legends of the past.

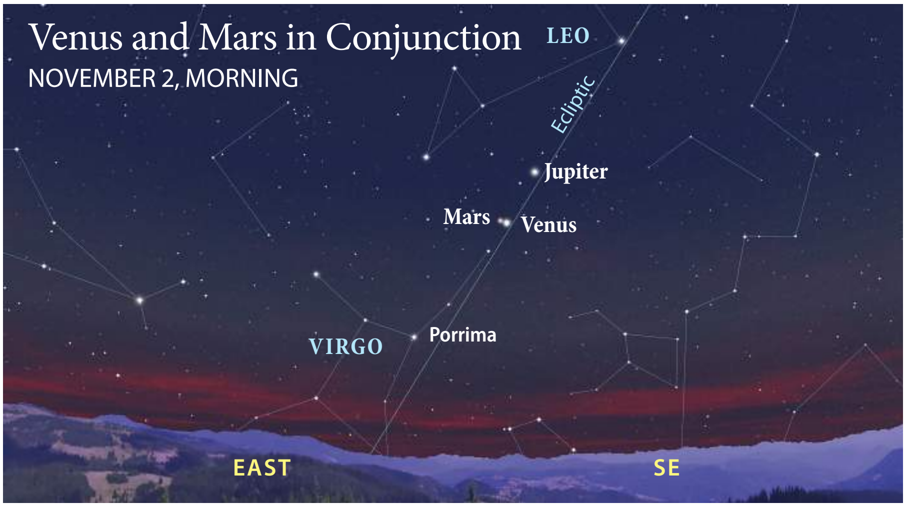
CONJUNCTIONS and a COMET AT DAWN

Circle November 7 and December 7 on your celestial calendar for impressive sights in the dawn sky

by Alan Dyer

THE MORNING DANCE OF THE PLANETS we've been enjoying all through October continues into early November, with a final meeting of Mars and Venus on November 2. The planets then go their own ways, as Venus drops down toward the Sun while Mars climbs higher. On November 7, the planet dance ends with a grand finale, as the waning Moon joins Venus and Mars for a superb conjunction in the morning sky.

A month later, we are treated to another meeting of the Moon and Venus, this one very close, indeed, with the bonus of a (possibly!) bright comet in the same binocular field. Comet Catalina may continue to put on a good show as it rises higher into our December dawn sky.



DOUBLE 'STAR' AT DAWN The season begins with Venus and Mars very close in the morning sky, performing the last in a series of conjunctions that occurred over the previous two weeks, in late October. On November 2, Venus and Mars are just ¾ degree (45 arc minutes) apart. The pairing shines 6½ degrees below Jupiter, facing page, close enough to squeeze all three worlds within a binocular field.

COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP. (BOTH)

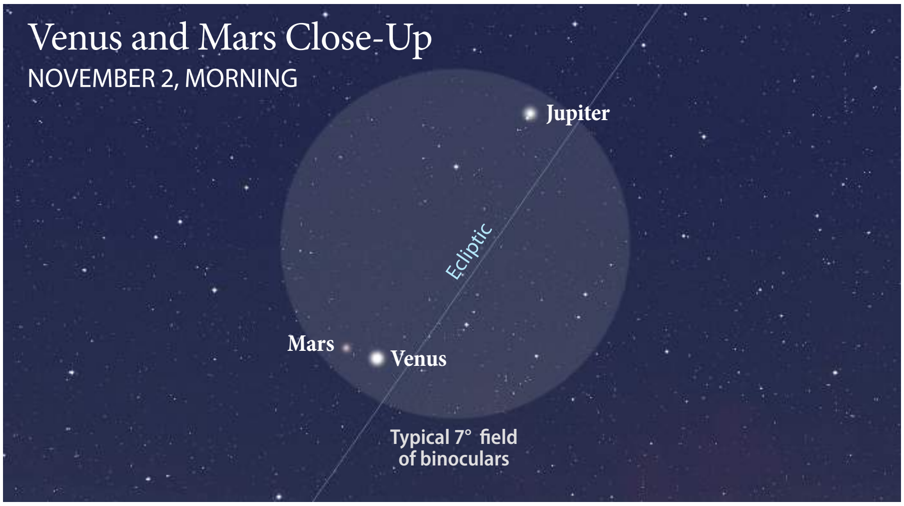
COMET AT DAWN Comet Catalina (C/2013 US10) promises to be a decent sight in our morning sky at year-end. It may resemble Comet PanSTARRS (C/2014 Q1), a morning comet from early July that was just visible to the naked eye. With its twin tails, PanSTARRS made a fine photographic subject in this image taken from the Atacama Desert, in Chile. PHOTO BY MALCOLM PARK

DAWN SKY GATHERING IN NOVEMBER

Throughout October, Venus, Mars and Jupiter danced around one another in the autumn dawn. The choreography reached its peak in late October as the three planets clustered within 4.5 degrees of one another between October 23 and 28, the closest we'll see these planets together until November 2111.

As November 2015 opens, Jupiter is climbing away from Venus and Mars, breaking up the trio. But Venus and Mars have one last fling with each other. On November 2, the two worlds pass with a separation of only ¾ degree. The pairing is close but mismatched, with Venus outshining Mars by some six magnitudes.

The colour contrast should be apparent, however, with the duo appearing as a bright white and dim red double "star" in the dawn sky. Use binoculars or a telescope to enjoy the view. With a separation of just 45 arc minutes, Venus and Mars appear close enough to frame in any telescope at low to medium power. With typical seven-power binoculars, you'll also be able to take in Jupiter shining above the Venus-Mars pair.



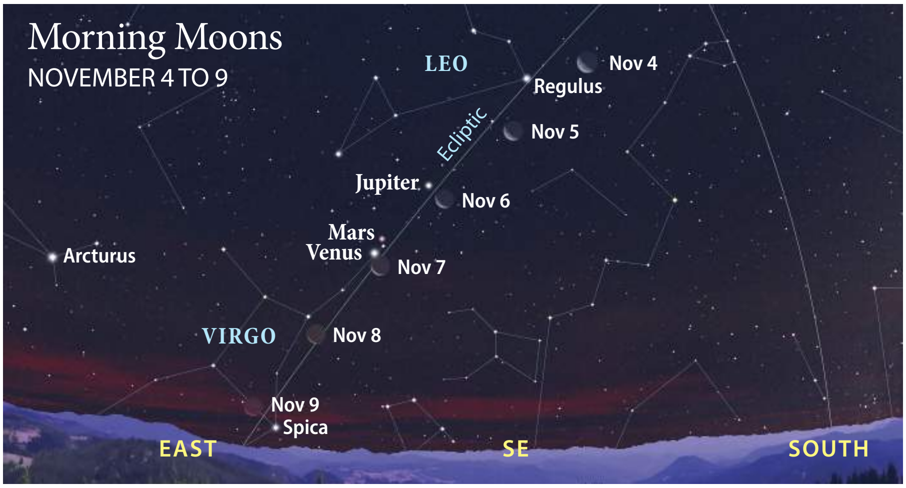
The real treat for binocular fans comes five mornings later, on November 7. That's when the waning crescent Moon joins Venus and Mars for a tight grouping easily contained within a four-degree field of high-power binoculars. Look for Earthshine lighting the "dark side of the Moon," an effect created by sunlight bouncing off Earth and lighting the Moon's nightside.

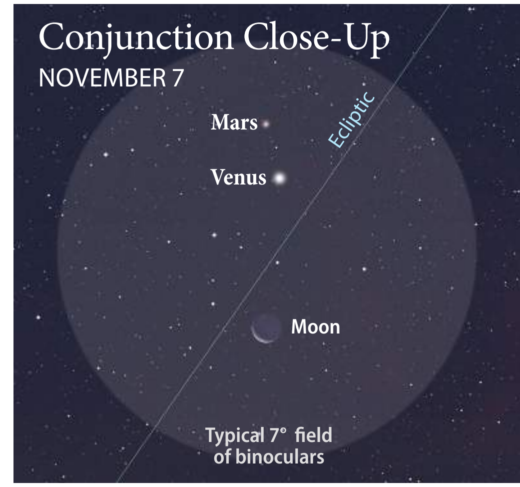
This is an excellent photo op, to be sure. The trio of worlds will be shining to the east-southeast, so plan to travel to a site with a scenic foreground in that direction to complement the celestial sight above. As the sky begins to brighten with morning twilight, a normal or moderately wide-angle lens should nicely frame the conjunction above your earthly scene.

DAWN SKY GATHERING IN DECEMBER

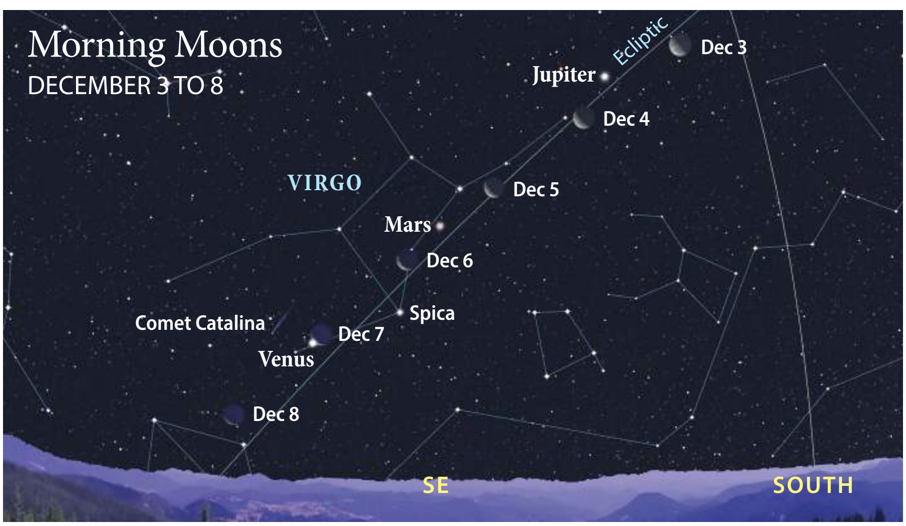
A month later, the Moon returns to the morning sky for a series of pairings with the planets, now lined up at dawn. On December 4, the crescent Moon passes three degrees below Jupiter, then shining at magnitude –2.0 near the Leo-Virgo border.

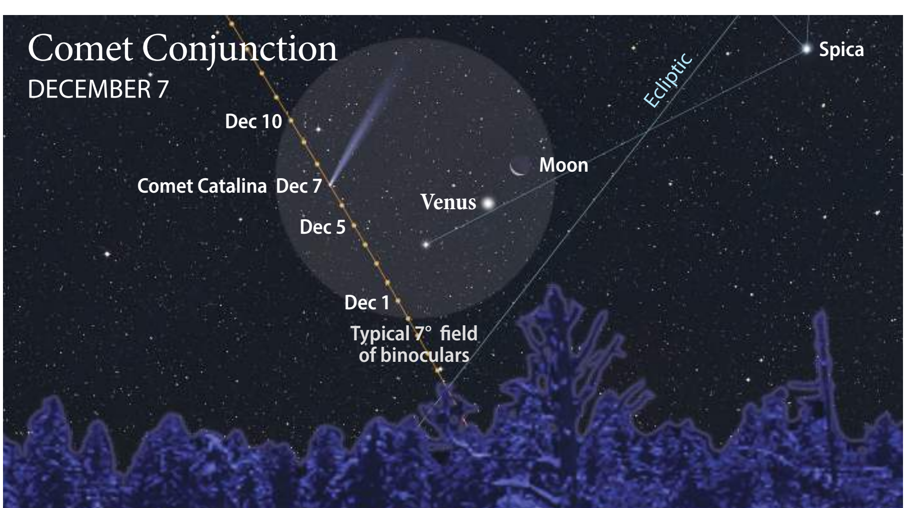
The next morning, the Moon is about five degrees above dim Mars. A day later, on December 6, the Moon sits below Mars, putting it about halfway between the red





NOVEMBER DAWN PLANETS During the week following their close conjunction, Venus and Mars pull apart, but the waning crescent Moon enters the scene. It passes two degrees below Jupiter on November 6, then joins Venus and Mars for a superb three-world meeting on November 7. The Moon appears 2.5 degrees below Venus and 3.5 degrees below Mars, allowing all three worlds to fit within a binocular field with room to spare. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP. (BOTH)





DECEMBER DAWN PLANETS By the first week of December, the three morning planets—Venus, Mars and Jupiter—have spread out across the eastern dawn sky. The waning Moon passes Jupiter on December 4, then shines between Mars and Spica on December 6. But the next morning, December 7, is the one to note. As shown above, the Moon sits just one degree from Venus, with Comet Catalina within a binocular field 4.5 degrees away. The orange dots mark the comet's position at daily intervals. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP. (BOTH)

planet and blue-white Spica. While that's a fine lineup of worlds, the best sight comes the following morning.

On Monday, December 7, the Moon shines just one to three degrees from brilliant Venus. The farther west you live in Canada, the closer the Moon will appear to Venus in your predawn sky. Those on the West Coast see a very close conjunction of the two brightest objects in the night sky, with the Moon less than a lunar diameter from Venus as the eastern sky brightens with dawn twilight.

That alone is a spectacular sight, nor does it demand rising too early, as the sky is still dark enough by 6:30 a.m. for a good view from most locations.

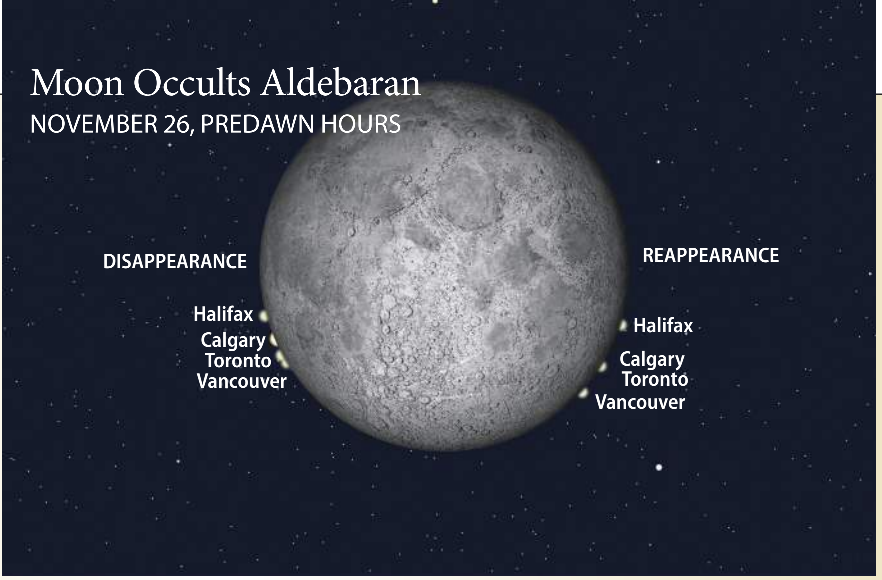
But the real bonus, which does require a dark sky and an early rise, is sighting Comet Catalina glowing just 4.5 degrees above the Moon-Venus pair. More about Catalina later, but suffice it to say for now that the morning of December 7 promises to provide one of the best sights and photo ops of the year.

As with any comet, of course, for Catalina to deliver a great view, it has to perform at least as well as predicted. As of this writing, Comet Catalina has been brightening on schedule, suggesting that through most of December, it will shine at magnitude 4.8 to 5.0.

While that's not bright enough to be easily naked eye, should Catalina sport a classic tail, the comet could be a good binocular sight. Its proximity to the Moon and Venus on December 7 should afford a superb photo portrait of varied solar system worlds in the morning twilight.

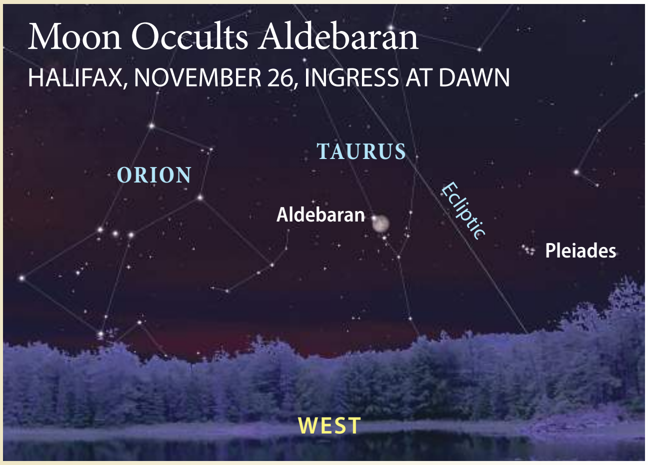
OCCULTATION OF ALDEBARAN

On November 26, the nearly full Moon passes in front of first-magnitude Aldebaran, in Taurus. All of Canada can witness this occultation, though it means rising at 2 a.m. to 6 a.m., local time. The reward: seeing one of the sky's brightest stars wink out behind the edge of the Moon, then snap back into view less than an hour later on the opposite limb. While Aldebaran is bright, the brilliance of the lunar disc demands a telescope.



LOCATION	ALDEBARAN DISAPPEARS	ALDEBARAN REAPPEARS
HALIFAX	6:40 A.M., AST	7:30 A.M., AST
MONTREAL	5:39 A.M., EST	6:30 A.M., EST
TORONTO	5:42 A.M., EST	6:31 A.M., EST
WINNIPEG	4:22 A.M., CST	5:20 A.M., CST
EDMONTON	3:01 A.M., MST	4:05 A.M., MST
VANCOUVER	1:56 A.M., PST	2:54 A.M., PST

STELLAR PASSAGES As the Moon travels from west to east against the background stars, it covers up stars—in this case, Aldebaran—on the left (lunar west) limb of the Moon. The star then reappears on the right (lunar east) limb of the Moon. As with any occultation, when and where Aldebaran disappears and reappears on the lunar limb depends on your location on Earth. COURTESY THESKYX™/SOFTWARE BISQUE



OCCULTATION FROM HALIFAX From Canada's East Coast, Aldebaran disappears (called "ingress") as the Moon sets into the western sky just before dawn on November 26. Reappearance happens 15 minutes before moonset, when the Moon is only one to two degrees above the horizon.

OCCULTATION FROM TORONTO From southern Ontario, Aldebaran reappears (called "egress") from behind the Moon about an hour before moonset, when the Moon is roughly 12 degrees high in the west and the sky is brightening with dawn twilight.
COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP. (BOTH)

DAYTIME DISAPPEARANCE

December 7 is a date to note for another reason. The Moon, which appears so close to Venus at dawn, continues to edge toward Venus after sunrise and through the morning. Later in the day, the Moon passes in front of Venus, occulting it for an hour or more in a daytime event visible all across Canada.

The farther east you live, the later in the day the occultation occurs. Those on the West Coast arguably have the best view, as Venus disappears behind the bright limb of the Moon just at sunrise, making the event potentially visible to the naked eye if the dawn sky is very clear. The reappearance 90 minutes later, however, will require optical aid to see in the bright daytime sky.

Elsewhere in Canada, seeing any aspect of the Venus occultation in the day sky will require at least binoculars or, better yet, a telescope despite its involving the two brightest celestial objects after the Sun. The brilliance of the day sky washes out the crescent Moon, perhaps making it a challenge to find, especially if your skies are hazy.

To guard against this, set up a polar-aligned, equatorially mounted telescope before sunrise, then leave it tracking the Moon through the day with its motor running at the lunar drive rate. Also, be sure to prefocus a low-power eyepiece at night to aid in finding the Moon by day.

As an alternative, you can set up and align a GoTo telescope the night before. Then park it, and place it into "sleep" or

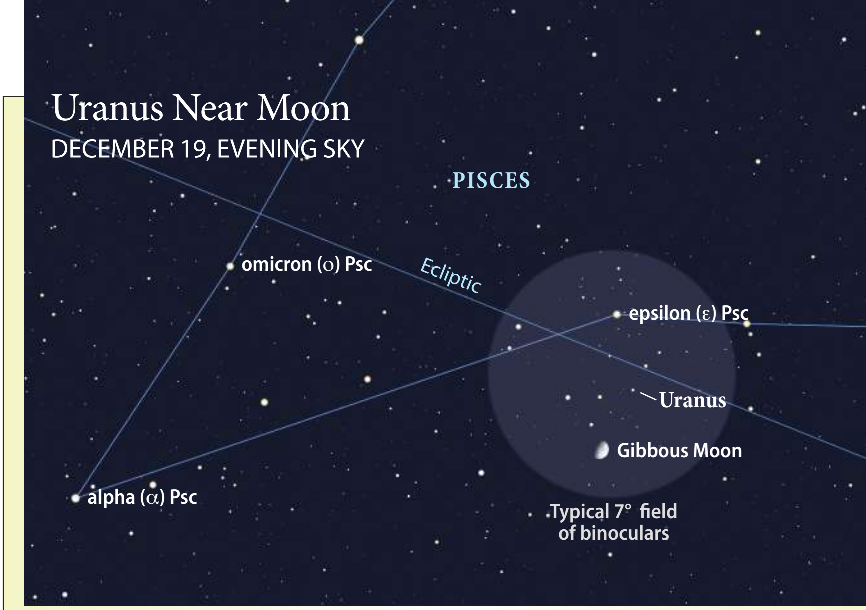
"hibernate" mode so that the telescope remembers its position. Wake it up the next day, and it should be able to accurately "go to" the Moon or Venus.

But do so well before the predicted time of disappearance, or you might miss the event. The Moon will take about a minute to cover up the disc of Venus. Even in the day sky, the bright edge of the Moon, while pale, should be obvious in the eyepiece, though much less so than the intense planet Venus.

Unlike our illustration below, however, the opposite dark edge of the Moon will be invisible against the bright sky. As a result, Venus will reappear into a clear blue sky, likely catching you by surprise.

MOONLESS METEOR SHOWERS

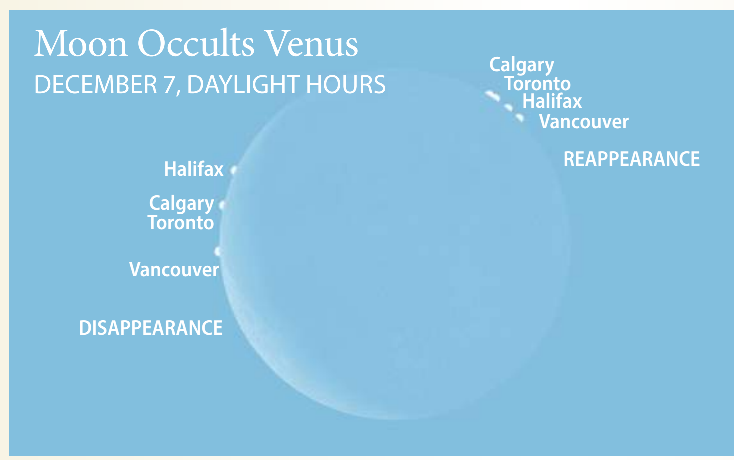
Every year brings a selection of annual meteor showers. Two of the best-known in the late-autumn and early-winter season



FINDING URANUS On December 19, the gibbous Moon passes two degrees below Uranus, which itself lies two degrees below the fourth-magnitude star epsilon Piscium. Despite the Moon's glare, sighting 5.8-magnitude Uranus should be possible, even in binoculars, and certainly in a telescope, making this a good night to track down the seventh planet. COURTESY THESKYX™/SOFTWARE BISQUE

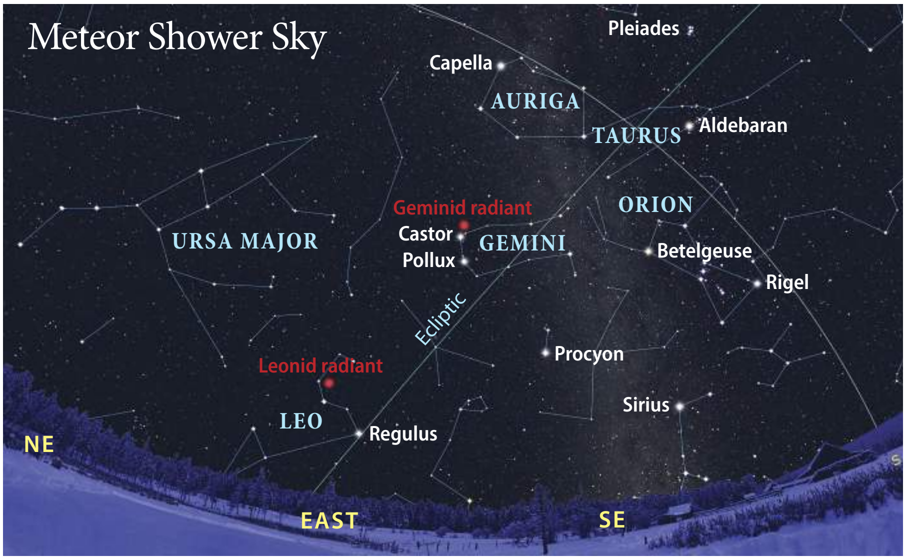
OCCULTATION OF VENUS

After sunrise on Monday, December 7, the crescent Moon edges closer to Venus and then occults it during daylight hours in an event visible across the country



PLANET PASSAGES Venus disappears behind the thin crescent of the waning 26-day-old Moon, an event that will be easy to catch in a telescope, even in the bright daylight sky. However, Venus will reappear from behind the dark limb of the Moon, which, unlike the illustration at right, won't be visible as a distinct edge. Venus will simply reappear into what looks like empty blue sky. Note the times below, and watch the expected area of sky carefully to see its disc uncovered by the Moon over less than a minute. COURTESY THESKYX™/SOFTWARE BISQUE

DISAPPEARANCE AT SUNRISE For most of Canada, Venus disappears behind the Moon well after sunrise. From the West Coast, however, the ingress of Venus happens just at sunrise, making the sky somewhat darker, with the Moon and Venus perhaps both visible to the unaided eye. But no matter where you observe from, a telescope at modest power will reveal the gibbous phase of tiny Venus, above right.
COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP. (BOTH)



RADIANTS RISING This chart depicts the sky for the November 17 Leonid meteor shower and for the December 13 Geminid shower. For the Leonids, you will have to stay up until 1 a.m. to see the radiant point in Leo rise this high above the eastern horizon. For the Geminids, on December 13, the radiant point in Gemini rises at sunset and climbs as high as is shown here by midnight, making it the more convenient of the two meteor showers to watch. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP.

TELESCOPE VIEW This photograph of the daylight occultation of Venus on August 13, 2012, provides a preview of what you can expect to see through a telescope on December 7 if your morning daytime sky is very clear. Venus will be obvious, shining far brighter than the pale crescent of the Moon, which can be a challenge to see in the daytime sky. PHOTO BY ALAN DYER

LOCATION	VENUS DISAPPEARS	VENUS REAPPEARS
HALIFAX	1:47 P.M., AST	1:46 P.M., AST
MONTREAL	12:38 P.M., EST	1:35 P.M., EST
TORONTO	12:32 P.M., EST	1:36 P.M., EST
WINNIPEG	10:54 A.M., CST	11:58 A.M., CST
EDMONTON	9:17 A.M., MST	10:29 A.M., MST
VANCOUVER	7:53 A.M., PST (SUNRISE)	9:23 A.M., PST

are the Leonids and the Geminids, named for the respective constellations from which the meteors appear to radiate.

This year, the Leonids peak on the night of Tuesday, November 17, and into the wee hours of November 18. Watching Leonids always requires a late night because the radiant point of the shower, in the head of Leo, doesn't rise until about midnight. You'll have to be a dedicated meteor watcher, as the Leonids, though famous for rare storms, usually produce only 10 to 20 meteors an hour, even under ideal conditions.

Fortunately, we enjoy nearly ideal conditions this year. The Leonids coincide with a waxing crescent Moon that sets around 10:30 p.m., local time, perfect for providing a dark, moonless sky just when needed, as the radiant rises at the midnight hour.

The same is true of the Geminids, which occur a month later. This shower ranks as one of the year's best, as good as or better than the popular Perseids of August. If you are under a clear, dark sky, expect to see about 50 to 70 meteors an hour, all shooting out of the constellation Gemini. And the radiant point is well up in the east in the early-evening hours.

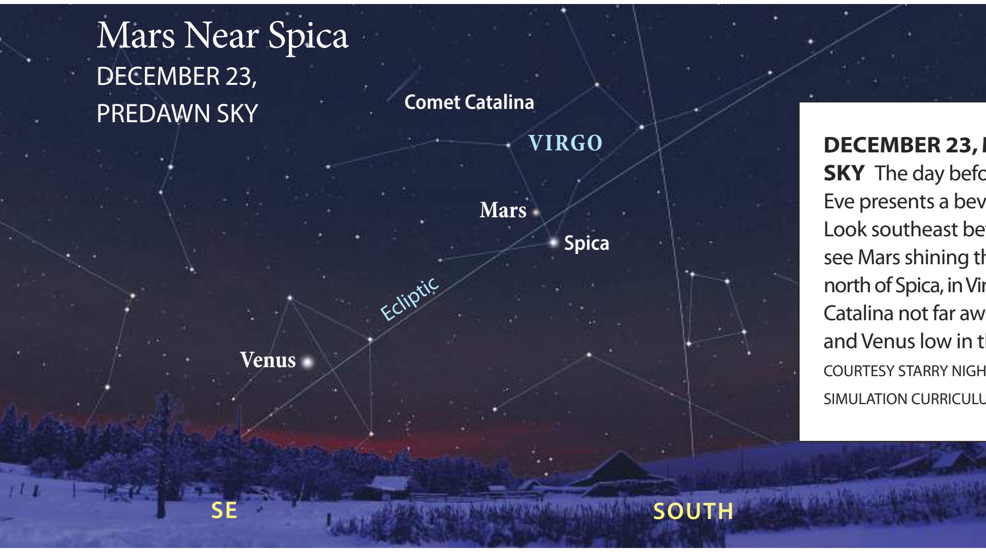
Better yet, on the two peak nights of Sunday, December 13, and Monday, December 14, the waxing crescent Moon sets in the early evening, leaving most of the night dark for meteor watching. Perfect!

The only downside this year is that for North America, the actual peak hour for the Geminids occurs in the middle of the day on December 14, thus my suggestion that both December 13 and 14 will be equally good for Geminid gazing. Of course, the main drawback to this shower is the weather. A Geminid watch can be a chilly affair. However, the abundance of Geminids, their slow speed and their long duration can make for a rewarding meteor watch worth enduring the winter cold.

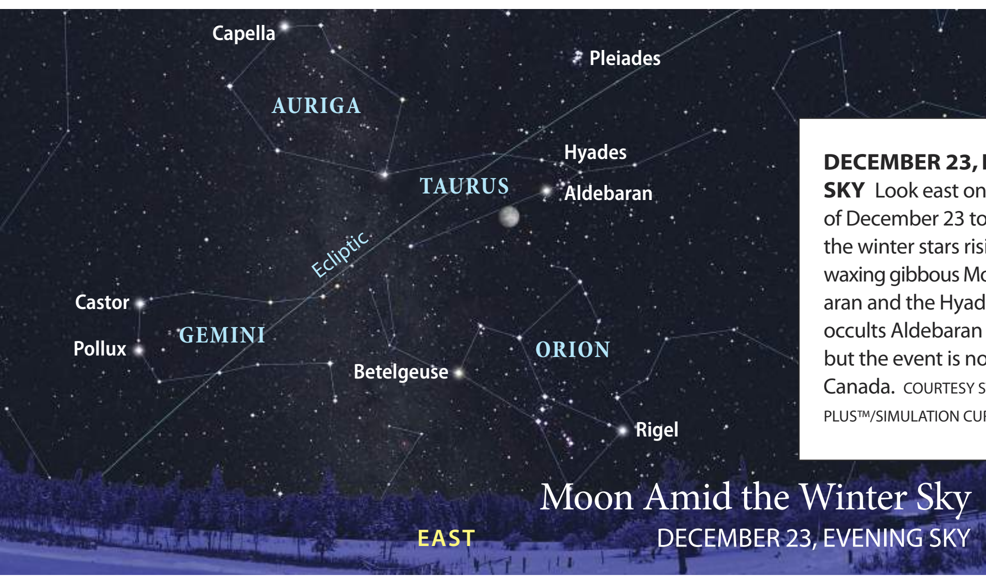
HOLIDAY SKY SIGHTS

Holiday week at year-end brings a handful of celestial attractions to watch for amid your celebrations. On December 23, the day begins with a view of Mars, now in Virgo, passing above the bright star Spica in the dawn sky. Mars shines within three degrees of Spica for the next three mornings. Comet Catalina isn't far away to the north, so if you have not yet seen it, take a look with binoculars.

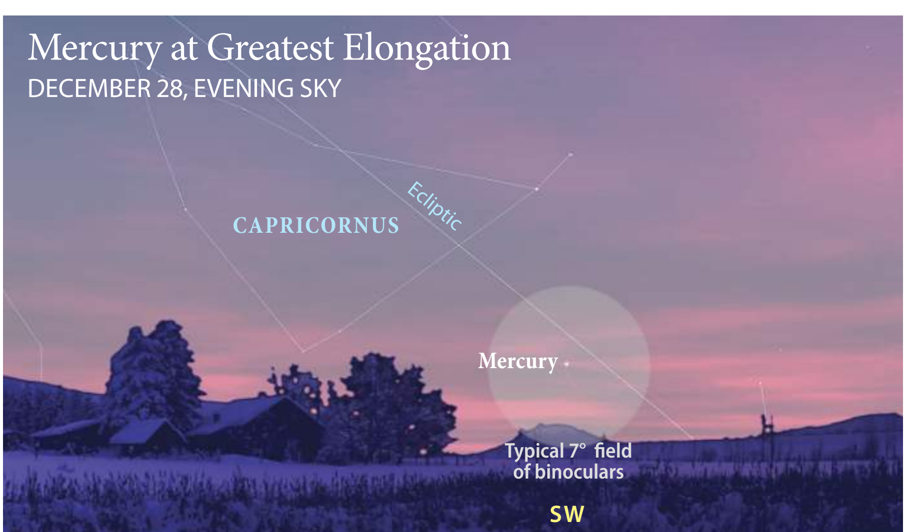
December 23 ends with an evening



DECEMBER 23, MORNING SKY The day before Christmas Eve presents a bevy of sky sights. Look southeast before dawn to see Mars shining three degrees north of Spica, in Virgo, with Comet Catalina not far away to the north and Venus low in the southeast. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP.



DECEMBER 23, EVENING SKY Look east on the evening of December 23 to see Orion and the winter stars rising, with the waxing gibbous Moon near Aldebaran and the Hyades. The Moon occults Aldebaran this month, but the event is not visible from Canada. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP.



INNER-PLANET APPARITION Although spring brings the best opportunity for sighting Mercury, the end of December provides a decent appearance of the inner planet as it reaches its greatest elongation from the Sun on December 28. Look for a bright object (magnitude –0.5) within a binocular field of the horizon in the southwest. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP.

scene of the waxing gibbous Moon shining not far from Aldebaran, in Taurus. As the Moon rises that evening, we in Canada see it pulling away from Aldebaran, which it had occulted a few hours earlier in an event visible from Europe and Africa.

As the year ends, Mercury appears briefly in our evening sky in a reasonably favourable elongation. The inner planet's maximum angle from the Sun comes on the evening of December 28. Look low in the southwest. Although Mercury is bright, it is easy to miss in the twilight. Other than this appearance by Mercury, no planet is visible to the naked eye in the evening sky this season. Saturn is now behind the Sun, while Venus, Mars and Jupiter all shine in the late-night to dawn sky.

In the year-end midnight sky, look to the east to see the waning gibbous Moon passing Regulus on December 28 and 29. The Moon then swings near Jupiter on December 30 and 31. On New Year's Eve, the waning Moon rises around midnight, shining below Jupiter, a sight to enjoy when taking in your local First Night fireworks display.

COMET CATALINA AT DAWN

Might we have a nice Christmas comet this year? We've heard that before and been disappointed. Any predictions of how bright comets might appear are fraught with uncertainty. Comet ISON in December 2013 fizzled as it rounded the Sun. By contrast, Comet Lovejoy in January 2015 surprised everyone with a wonderful show, though one best appreciated with binoculars or a camera.

Comet Catalina (a.k.a. C/2013 US10) was discovered on October 31, 2013, from the Catalina Observatory near Tucson, Arizona, as a by-product of an asteroid search program. It orbits in a highly inclined path tilted 149 degrees off the plane of the Earth's orbit, the ecliptic. Catalina is thought to be a first-time visitor arriving from the distant Oort cloud. As such, it has no track record of performance. Astronomers can make

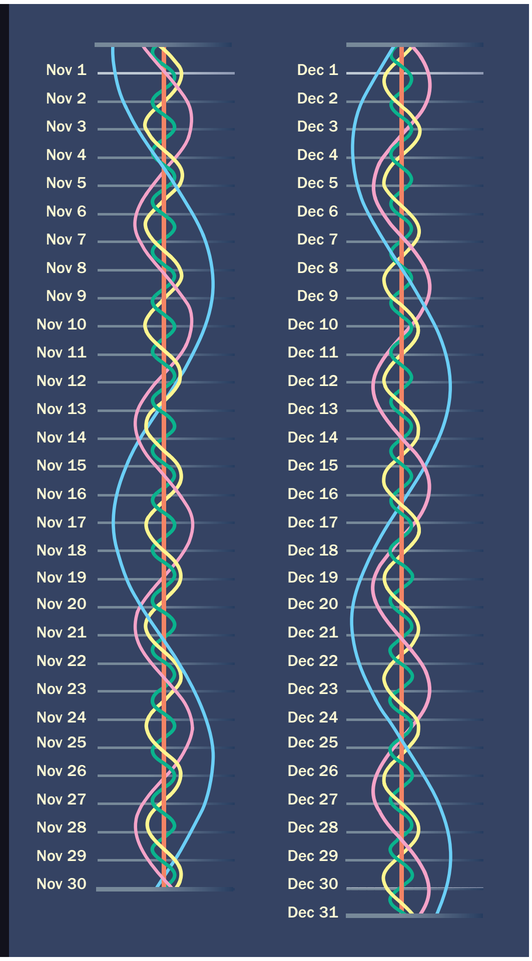
JUPITER'S MOONS

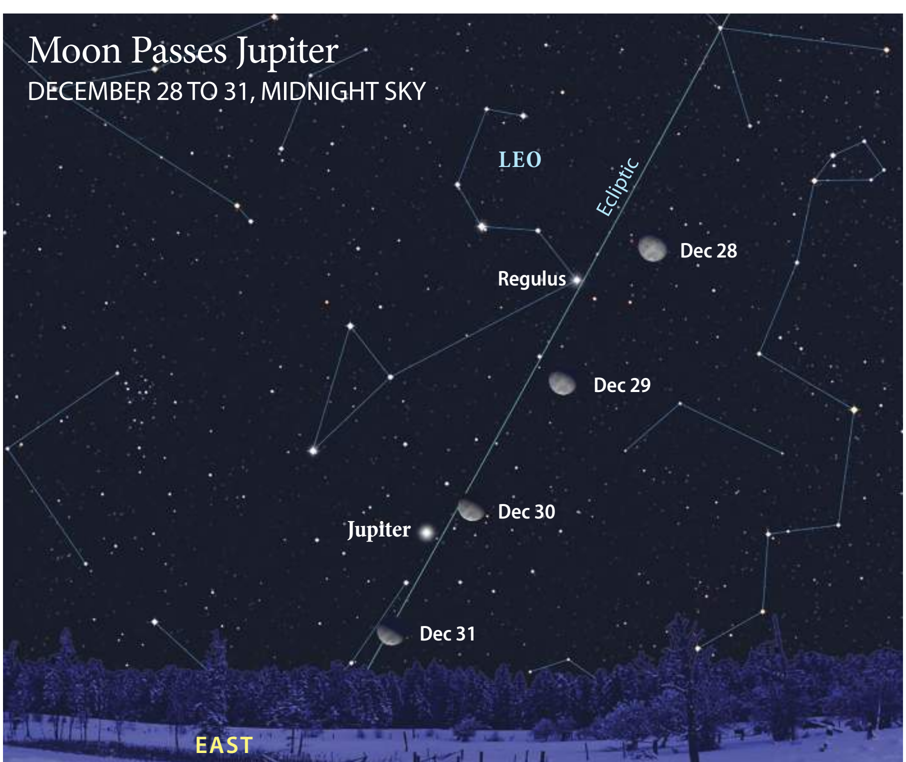
November and December 2015

The positions of Jupiter's four largest moons are shown for each night of the two-month period. Jupiter is represented by the central vertical shaft, while the moons are the four wavy lines. The horizontal lines mark 8 p.m., EST, on the dates indicated. Time flows from top to bottom, so look proportionately below the line for later times on a particular date. East is to the left, and north is at the top, as seen in binoculars. From closest to farthest, the moons are Io, Europa, Ganymede and Callisto. Orbital periods are 1.8, 3.6, 7.2 and 16.7 days, respectively.

KEY:

Io — Europa — Ganymede — Callisto



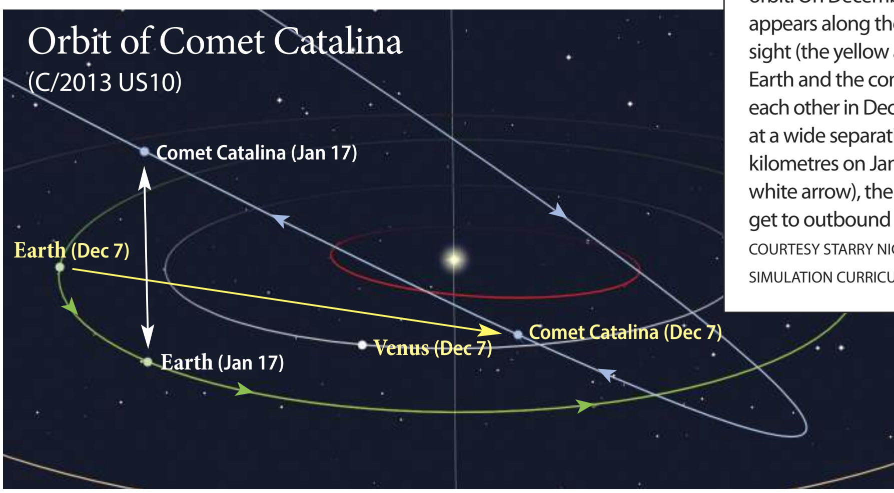


YEAR-END SKY As 2015 comes to a close, look east at midnight to see the waning Moon pass by Regulus on December 28 and 29. It is then near Jupiter on December 30. On New Year's Eve, the Moon rises below Jupiter as the year turns to 2016. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP.

predictions of its brightness based only on what a typical comet does.

Nor will it ever return. After its brief day in the Sun, the comet will be flung out of our solar system into interstellar space. Perihelion, when Catalina is closest to the Sun, occurs on November 15 at a relatively distant 122 million kilometres from the Sun. Unlike 2013's ill-fated Comet ISON, this icy object from deep space is no sungrazer.

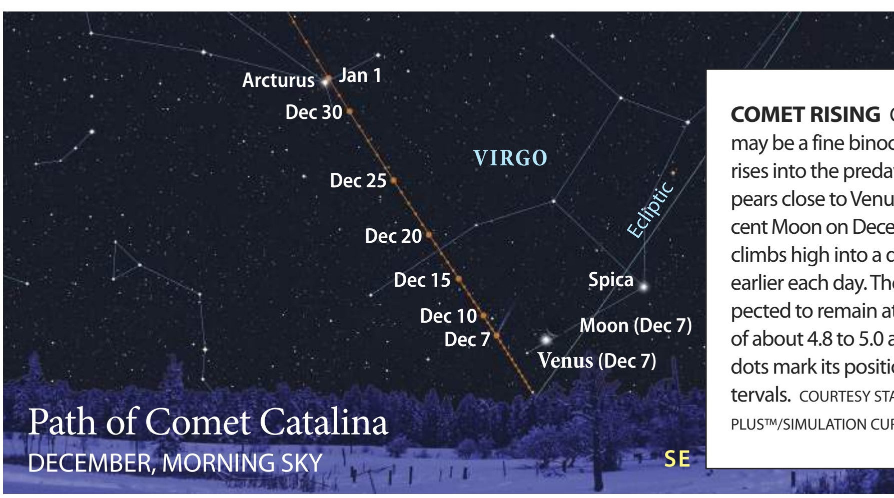
After perihelion, Catalina emerges from behind the Sun from our perspective and climbs high into our northern morning sky, making it easy to sight in a darkened sky through December and into January. For most of that time, Earth and the comet approach each other, with our decreasing distance compensating for the comet's declining brightness as it slowly recedes from the Sun.



HERE AND GONE Comet Catalina (C/2013 US10) enters and leaves the inner solar system on a highly inclined and elongated orbit. On December 7, the comet appears along the same line of sight (the yellow arrow) as Venus. Earth and the comet approach each other in December, then pass at a wide separation of 108 million kilometres on January 17 (the white arrow), the closest we will get to outbound Comet Catalina. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP.

As a result, Comet Catalina is expected to remain at a fairly constant magnitude of 4.8 to 5 throughout December and early January. We are closest to the comet on January 17, although still with a generous 108 million kilometres between us. After that date, Catalina fades rapidly, dropping to magnitude 6 by the end of January and to magnitude 8.5 by the end of February.

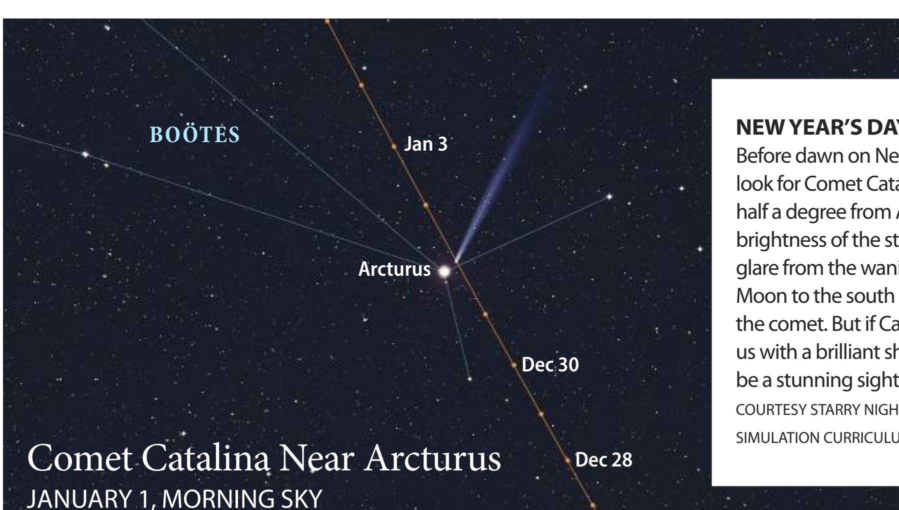
A fifth-magnitude comet is usually a fine binocular sight and is an excellent subject for wide-field photos. But it's no naked-eye spectacle. Even at that, Catalina will have to sport a decent tail to become truly photogenic and not just a fuzzball. What will it do? How will it look? Only time will tell.



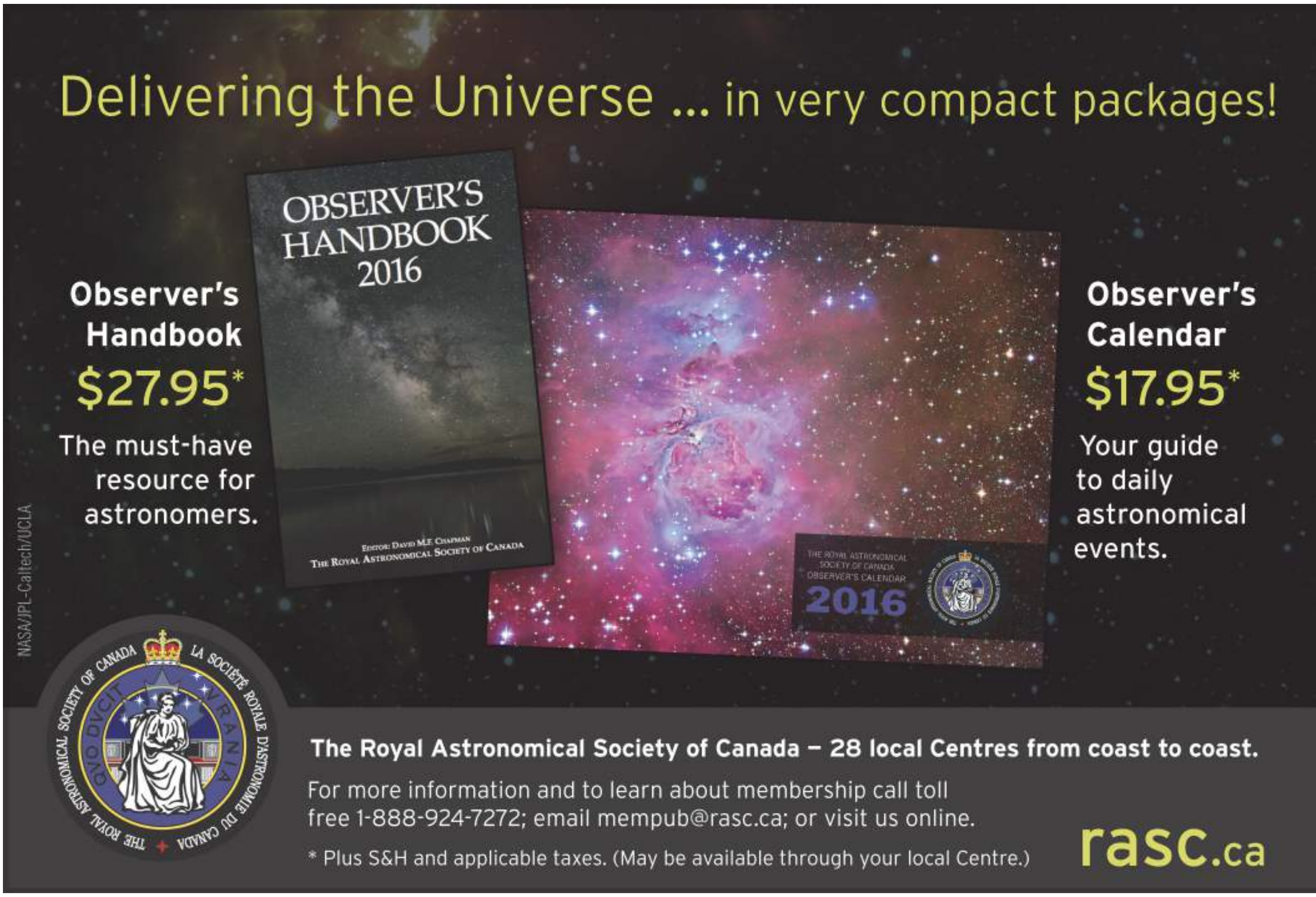
COMET RISING Comet Catalina may be a fine binocular sight as it rises into the predawn sky. It appears close to Venus and the crescent Moon on December 7, then climbs high into a dark sky, rising earlier each day. The comet is expected to remain at a magnitude of about 4.8 to 5.0 all month. The dots mark its position at daily intervals. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP.

What we *can* say is that the comet's highly inclined orbit works to our advantage, swinging Catalina high into our eastern dawn sky on a path that takes it through Virgo in December, then up into Boötes and Canes Venatici in early January. By mid-January, the comet is travelling above the handle of the Big Dipper, passing near the galaxy M101 on January 16, the day before its closest approach to Earth.

A unique sight may await us during the wee hours of January 1, when the comet passes just ½ degree away from bright Arcturus. Will this be a superb sight, or will the comet appear as no more than a dim glow lost in the glare of the star? By December, when the comet reappears from behind the Sun, we will know whether Catalina is meeting or exceeding our expectations. (See skynews.ca in December for late-breaking news on the comet.) ✦



NEW YEAR'S DAY SPECIAL Before dawn on New Year's Day, look for Comet Catalina less than half a degree from Arcturus. The brightness of the star and the glare from the waning quarter Moon to the south may wash out the comet. But if Catalina surprises us with a brilliant show, this could be a stunning sight to start 2016. COURTESY STARRY NIGHT PRO PLUS™/SIMULATION CURRICULUM CORP.



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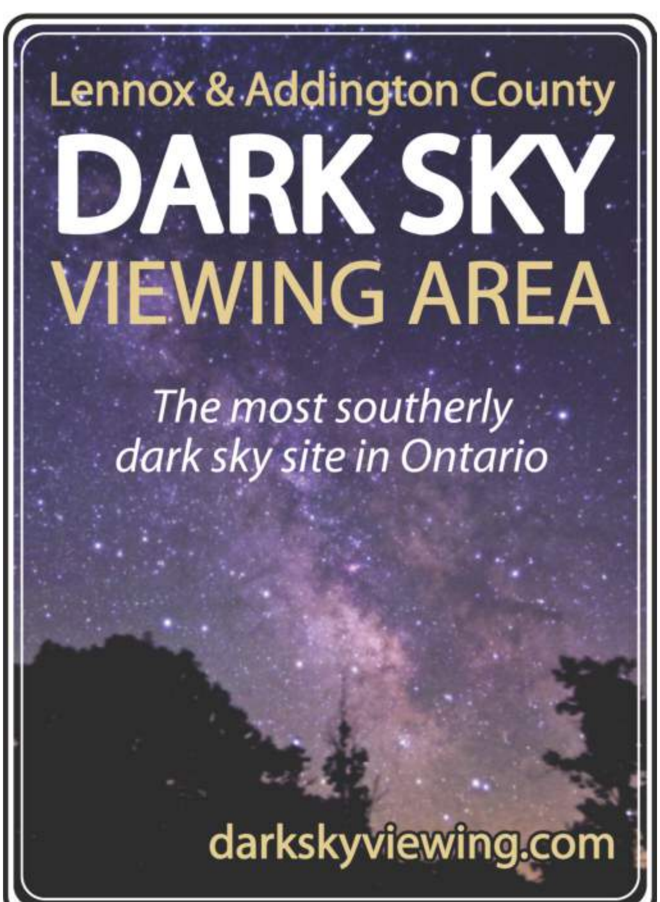

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Nikon's first specialized camera for astrophotographers is loaded with great features. We field-test it for *SkyNews* readers. *by Malcolm Park*

ISO WHAT?!! Under the pristine skies of the Atacama Desert in northern Chile, Malcolm Park set his new Nikon D810A at ISO 51,200 with a 70mm f/4 lens for this 10-second single-frame exposure "as an experiment." Having this part of the Milky Way directly overhead helped…but wow!

BEFORE THE RELEASE OF THE D810A this past summer, Nikon had not manufactured a Hydrogen-alpha (Ha) filter-modified camera for astrophotography. Canon had released two Ha-enhanced versions of earlier models for astrophotography—the 20Da (in 2005) and the 60Da (in 2012)—leaving Nikon night-sky shooters waiting until now. I was one of them. As a longtime Nikon user with a shelf full of Nikon lenses, I ordered early and have been using the camera since June.

Why is an Ha filter-modified camera better for astro-imaging than a regular DSLR?

The primary reason is that the internal infrared (IR) cut-off filter on the modified camera permits four times as much of the deep red 656nm wavelength of Ha emissions through to the sensor than do nonastrophotography DSLR models. To see why, I'll back up a bit.

All normal digital cameras primarily intended for daytime use are "tuned" for the visible spectum, and an internal infrared/UV filter does this without the camera user being aware of it. But the filter cuts most of the red from celestial objects—particularly glowing nebulas in the night sky, such as the Orion Nebula and the Lagoon Nebula. Astrophotographers know that Ha sensitivity greatly enhances images, and therefore, filter-modified DSLR cameras are preferred, despite their higher price.

The unmodified D810 was already one of Nikon's top models, with excellent colour rendition and low noise at high ISO settings. Adding improved Ha sensitivity to this camera has made it an excellent astro-DSLR. The colour rendition in stars and in subjects such as the multiple hues of the Rho Ophiuchi region (page 38), for example, is vibrant.

Until very recently, the 36-megapixel specification of the D810A would have been regarded as a disadvantage for an astro-camera. A smaller pixel count means larger pixels in the sensor, each better able to soak up faint celestial light sources—or so we

NIKON VS. CANON We tested the Nikon D810A (left) against its closest rival, a Canon 6D with a filter modification by Hutech (right). These two shots of the North America Nebula, in Cygnus, are greatly enlarged and heavily cropped from 30-second exposures taken at ISO 6400 at the same time and the same location. Both cameras were fitted with 50mm Sigma Art lenses at f/2.8. The skies were excellent at the zenith, where Cygnus was riding high. Location: Lennox & Addington County Dark Sky Viewing Area, north of Napanee, Ontario. Apart from the different colour renderings by the two systems, the Canon image is a bit noisier than the Nikon photo. More obvious are the fainter stars recorded by the Nikon sensor's smaller pixels (see "Gulf of Mexico" area).

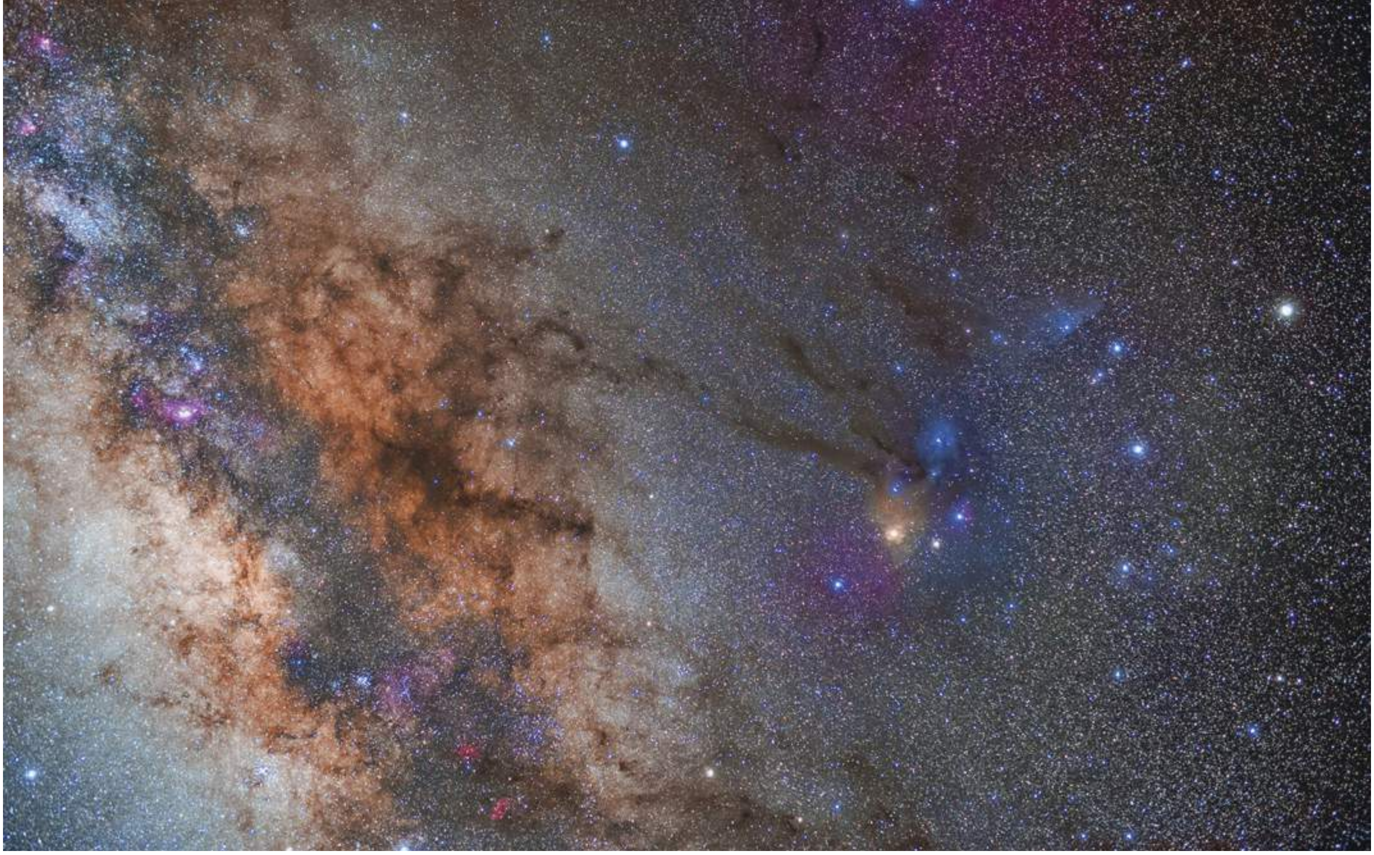
thought. But judging by the Nikon D810A results, sensor technology seems to have moved forward. Everything is sharper, and faint stars are smaller, with more room to crop, if desired. A direct comparison with images from the top-rated 20-megapixel Canon 6D (introduced in 2012) clearly shows the 36-megapixel Nikon imaging fainter stars with equivalent exposures. Nebulas look similar in both images, but further testing is under way to quantify this.

A very useful feature of the Nikon D810A is a new shooting mode: M*. Similar in all respects to the M (Manual) mode to which Nikon shooters are accustomed, it has added preset exposure times, ranging from 4 seconds to 900 seconds. Also, exposures of 4 seconds or longer can be shot in continuous shooting mode, either until the card is filled or until the battery is drained. No gaps in star trails. No buffer issues. And there is an M* setting called "Time" that acts like a bulb: One shutter click opens the shutter; another click closes it. This allows you to take specifically timed shots easily.

The live-view function has been enhanced for astrophotography. When live view is on, the "OK" button on the back of the camera acts as a switch, boosting the brightness of the live-view screen on or off. This helps when focusing on fainter stars.

The D810A has been improved over some earlier models by extending the maximum number of shots from 999 to 9999. Meteor-shower and time-lapse shooters who want to leave their cameras running all night will like this change. For the longer nights, 999 was not enough frames to use the on-camera intervalometer. The intervalometer can also handle HDR image sets of up to 9999 x 9 frames (for those who are shooting HDR time lapses).

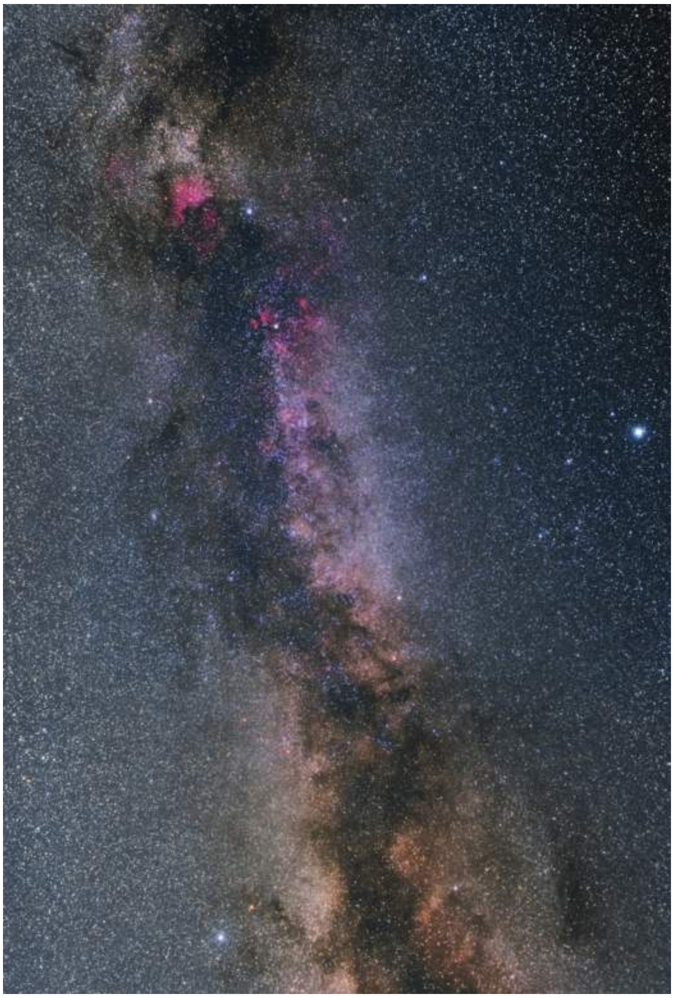
The on-camera, time-lapse function allows you to create time-lapse movie sequences without having to process a video later from hundreds of stills on a computer. The camera compiles the video



COLOURFUL RHO OPHIUCHI REGION The D810A picks up loads of detail when presented with the superb sky conditions of the Atacama Desert, in Chile. Malcolm Park used a 50mm Sigma Art lens at f/2.8 for this digital stack of five 4-minute exposures at ISO 1250.

BRIGHT AURORA From Thunder Beach on Georgian Bay, Ontario, Malcolm Park shot a 6-second exposure of an aurora display with the Nikon D810A at ISO 3200 using a 14mm lens at f/2.8.

SUMMER MILKY WAY FROM CANADA From the North America Nebula near Deneb (top) to Vega (right) and Altair (bottom), the Summer Triangle is a wondrous ribbon of stars for skywatchers. From his backyard near Bloomfield, Ontario, Malcolm Park used a 28mm lens at f/5 and ISO 1250 with the Nikon D810A. Five 240-second exposures were digitally stacked for the result at right.



for you and saves it as a .MOV file. This is very convenient if shooting an aurora or capturing the motion of the night sky when you want to keep it simple. You can always shoot still frames if you'd like. Time lapse is a nice option.

As astrophotographers know, finding buttons and scrolling through menu options, especially in the dark, can be challenging. Nikon's solution is to provide an option called "My Menu." Simply populate the menu with your most frequently accessed menu items. You can program a button on the camera to take you to this menu directly. In My Menu, I have LENR, the Levelling tool, Image quality, White balance, Time lapse and Intervalometer shortcuts, among others.

There is an electronic front-curtain shutter option that, when enabled while in mirror lockup mode, reduces the shake associated with the mirror flip when triggering the shutter.

One feature I wish Nikon had included on the D810A is the swivelling LCD screen that is on the D750. I also wish Nikon had copied Canon so that the camera could apply a single dark frame to multiple exposed frames.

Yes, the camera is expensive (north of $4,000), but it costs less than high-end, one-shot colour CCD astro-cameras and can be used quite nicely for daytime shooting as a regular DSLR, while an astro-CCD cannot. The D810A daylight scenes do not have the distinct pinkish cast that most filter-modified DSLRs do, so colour-balancing in Photoshop or other software is not necessary, nor is rebalancing the white balance between day and night use.

While I have a few minor wishes (a red-tinted cover for the LCD screen, for one), I am very pleased overall with this camera.

And, finally, a few words about the ISO 51,200 image on page 36. On a recent trip to the Atacama Desert in Chile, I thought I would try the maximum ISO to see how the image would look. I set the ISO to 51,200, stopped the Nikon 70-200mm f/2.8 lens down to f/4 and focused on Vega. I then slewed to the Lagoon Nebula, near the zenith, and took a 10-second exposure. The result was impressive. ✦

Malcolm Park, an experienced Nikon camera user, lives under dark skies in Prince Edward County, Ontario. He is former president of the North York Astronomical Association.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PERSEUS

Home of a celestial Samaritan and dazzling sky objects, the constellation Perseus lures us in for a closer look. But beware the severed heads! *by Ken Hewitt-White*

PERSEUS FEATURES a slender star pattern formed by a dozen mostly third- and fourth-magnitude stars. The exception is 1.8-magnitude alpha Persei, also known as Mirfak, a name that means "elbow." The inelegant moniker hardly reflects the stature of this yellow-white supergiant star some 4,000 times more luminous than our Sun. Think of Mirfak as the shining heart of Perseus—a gallant Greek hero who charged to the rescue of damsels in distress.

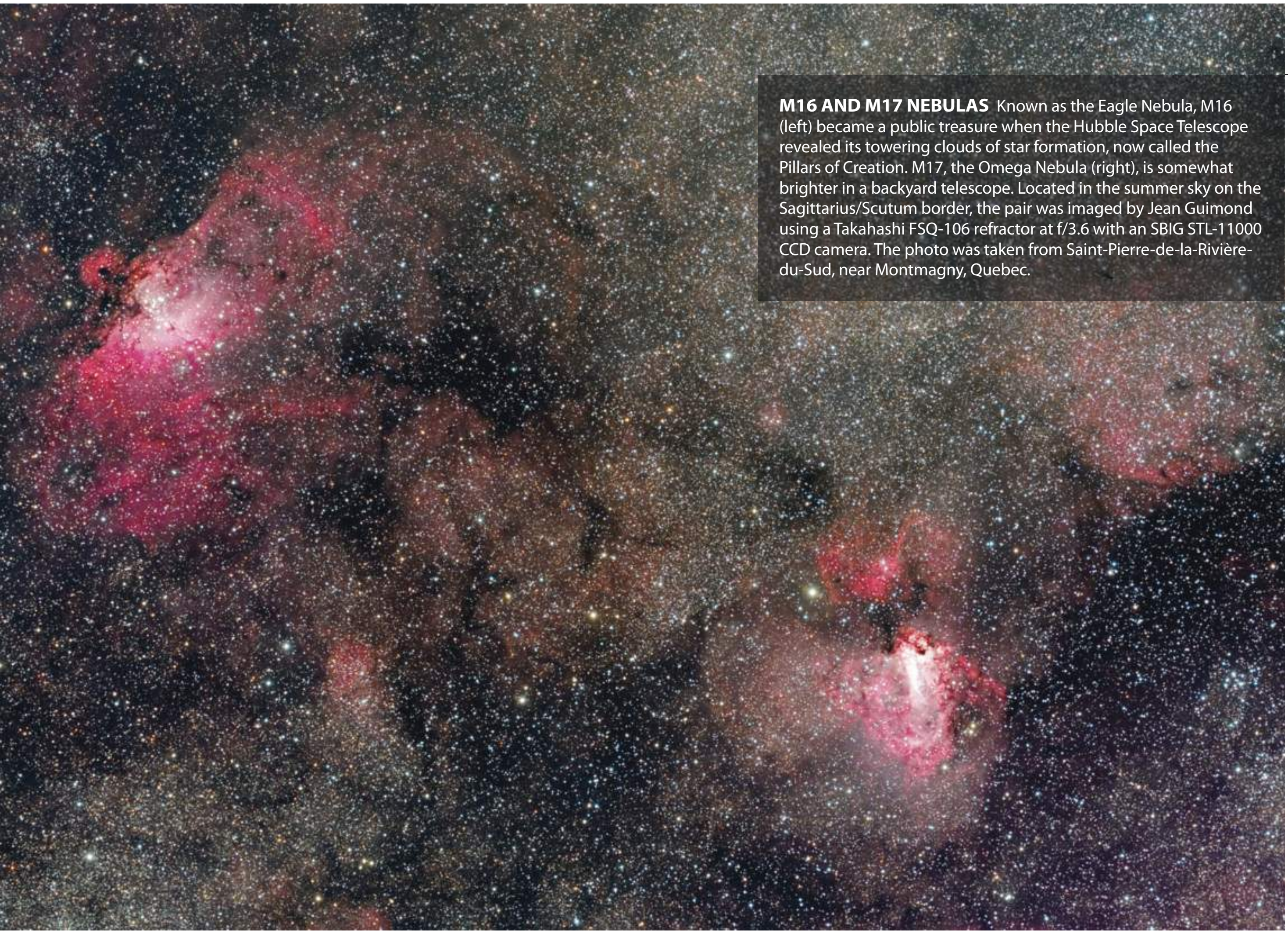
Perseus owed his strength to his father, Zeus, and his high moral fibre to an adoring mother, the princess Danaë. In an attempt to destroy Perseus, the scheming chieftain Polydectes (who had enslaved Danaë earlier) dared him to slay the Medusa, one of the hideous Gorgon sisters. The Medusa was a disagreeable woman with snake-infested hair, whose gaze would turn anyone instantly to stone. Clever Perseus eyed her safely via the reflection in his polished shield, then decapitated her.

On his way home, Perseus chanced upon the lovely princess Andromeda chained to a rock by the seashore. An enormous sea monster (represented in the heavens by the constellation Cetus) was about to devour her when our hero brandished his bizarre trophy head, turning the creature to stone. Perseus then confronted Polydectes and thrust the gruesome Gorgon in his face. Polydectes was literally petrified!

Medusa's evil eye is marked by 2.1-magnitude beta Persei, better known as Algol, the Demon Star. Algol is an eclipsing binary whose normally steady light dims by 1.3 magnitudes every third day. The rhythmic "wink" was considered malevolent by several ancient cultures. In Hebrew astrology, for example, Algol was the Head of Satan. Chinese lore regarded it as Tsi-chi, the heaped-up corpses of criminals who were executed every autumn.

The Chinese placed two more severed heads in this constellation, and they belonged to a pair of (gulp!) skywatchers. The ancient court astronomers Hsi and Ho partied too hard one day and failed to predict an eclipse of the Sun, a misdemeanour they paid for with their lives. The hapless duo is symbolized by the famous Double Cluster, a condensed patch of stars in the Perseus Milky Way.

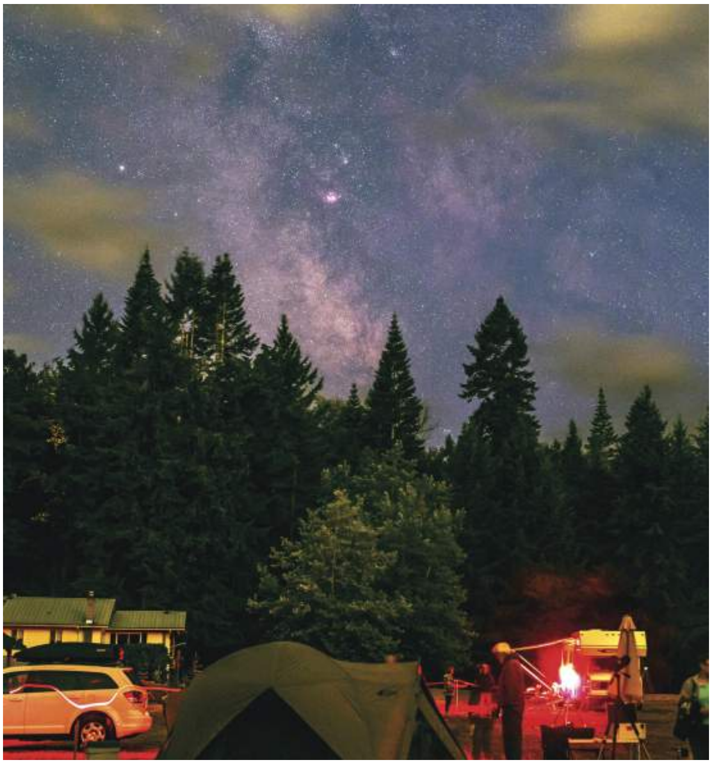
With its absorbing mythology and bright stars, Perseus is an area of the sky well worth scanning. But don't lose your head over it. ✦



M16 AND M17 NEBULAS Known as the Eagle Nebula, M16 (left) became a public treasure when the Hubble Space Telescope revealed its towering clouds of star formation, now called the Pillars of Creation. M17, the Omega Nebula (right), is somewhat brighter in a backyard telescope. Located in the summer sky on the Sagittarius/Scutum border, the pair was imaged by Jean Guimond using a Takahashi FSQ-106 refractor at f/3.6 with an SBIG STL-11000 CCD camera. The photo was taken from Saint-Pierre-de-la-Rivière-du-Sud, near Montmagny, Quebec.

FOR YOUR VIEWING PLEASURE

Some splendid distant nebulas and galaxies are within reach of backyard astro-imagers



▸**STAR PARTY TIME** This was the scene at the Island Star Party held in mid-August by the Cowichan Valley Starfinders at Bright Angel Park, on Vancouver Island. The clouds were finally receding as the Sun set, and everyone was out on the field preparing to take advantage of the clearing skies. Astrophotographer John McDonald recorded the scene using a modified Canon 6D camera with a Sigma 50mm lens operating at f/2.8 for the 8-second exposure at ISO 3200.

▲ **DEEP PEEP NEAR M81** Deep-sky aficionado Doris Thibeault imaged the large but faint MW3 nebula listed in the Mandel-Wilson catalogue of galactic integrated flux nebulas. Galaxy M81 is near top centre. A Takahashi FSQ-106 refractor at f/3.6 was used for 12 hours of exposure with an SBIG STL-11000 CCD camera from near the Rimouski Wildlife Reserve, in Quebec.

▲ **THIN CRESCENT VENUS** On August 14, Jean Guimond photographed the razor-thin Venus crescent in the daytime sky from Quebec City when the planet was one day from inferior conjunction. The image is a video capture using a Takahashi TOA-150 apo refractor.

▲ **BRIGHT SUMMER NEBULA** Ian Barredo took this lovely portrait of the Lagoon Nebula (M8) and its dimmer companion NGC6559 (at left) on June 21 from Cypress Hills Interprovincial Park, which straddles the southern boundary between Alberta and Saskatchewan. He combined three 10-minute exposures at ISO 3200, taken with a Nikon D610 DSLR camera attached to a Sky-Watcher 80mm apochromatic refractor telescope. The nebulas are about 5,000 light-years from Earth.

by Ken Hewitt-White

Postcards From Pluto

Classical planet? Dwarf planet? King of the Kuiper belt? Call it what you will, Pluto has worldly attributes after all.

LAST JULY 7, one week before its historic flyby of Pluto, the New Horizons probe transmitted a tantalizing glimpse of its far-off target. The image exhibited just two surface features: one dark and elongated, the other bright and heart-shaped. Nothing else stood out; the details were fuzzy. In short, it was the best picture of Pluto I'd ever seen.

My exposure to Pluto dates back to the 1960s, when the putative ninth planet possessed all the character of an extra-fine pencil dot. It wasn't until 1994 that the Hubble Space Telescope started mapping some vague albedo features on that pixel-sized dot. The Hubble scientists created a computer-generated globe (the first of several) whose patchwork of light and dark areas was the clearest evidence yet that Pluto boasted a strongly varied surface terrain. But what kind of terrain? The answers began arriving after New Horizons completed its spectacular encounter in mid-July. The real Pluto was unveiled at last.

Fittingly, a key member of the 1994 mapping team, planetary astronomer Alan Stern, became principal investigator of the New Horizons mission. I remember interviewing the dedicated Plutophile after his early Hubble work but before New Horizons was approved. Stern asserted that the Sun's least-appreciated planet (it would soon be demoted to dwarf planet status) was a potential gold mine of geological diversity and that a Pluto flyby would *not* disappoint. "The basic lesson of planetary exploration," proclaimed Stern, "[is that] everywhere we've sent a spacecraft—somewhere new, somewhere for the first time—we've been blown away by the richness and the variety that nature shows us." Pluto, he said, wouldn't be any different.

Stern made good on his promise. The stunning close-ups of Pluto and its main moon Charon (see page 10) put to rest any notion that these tiny, remote worlds might be bland and uninteresting places. Indeed, New Horizons has turned out to be yet another deep-space mission with scientific results so dramatic and unexpected, the experts have been compelled to rethink certain planetary processes (they love that, by the way). And, as with the many groundbreaking space projects before it, this initial probing of the mysterious Kuiper belt is more than just good science. The New Horizons mission is a testament to one of the fundamental attributes of the human condition: the desire to explore, to push back the boundaries of the unknown, to boldly go (in the spirit of "Star Trek") where no one has gone before!

PLUTO FROM 1.5 MILLION KILOMETRES Once the New Horizons spacecraft was within a week of its close encounter, a new world was revealed. COURTESY NASA

In my opinion, this urge to seek "new horizons" speaks to our better nature. A post-encounter newspaper editorial in the *National Post* agreed: "For all our many sins as a species, we still do, occasionally, make a point of doing right. There is nothing material to be gained by exploring Pluto. There is no strategic significance to the outer solar system, no natural resources worth claiming so far away. We sent out New Horizons purely and simply because we wanted to better understand our universe."

In a television feature about the mission, CBC "Quirks & Quarks" host Bob McDonald asserted, "That's why we explore. That's why we go places we've never been before. It's knowledge for the sake of knowing it."

Prior to New Horizons, our knowledge of Pluto grew at a snail's pace. The Hubble Telescope's ability to show a few Pluto markings was a major step forward for Alan Stern and collaborators David Tholen and Marc Buie. At the time, Stern, Tholen and Buie were three big fish in the relatively small pond of Pluto researchers. They lobbied hard for the NASA mission that would, ironically, relegate their hard-won results to the history books. "I always knew," quipped Buie recently, "that some day, I would have to give up my beloved Pluto to the geologists."

There's no denying Pluto is a tiny outlier. But the pip-squeak planet with the Disneyesque name enjoys a secure place in our sky lore. Everyone, it seems, loves Pluto. That's certainly true for the planetary scientists whose belief in Pluto as a world worth studying has finally been vindicated. A dwarf planet, yes, but one that punches well above its weight! ✦

Contributing editor Ken Hewitt-White observes the night sky from the mountains of British Columbia.